Engineering News

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A 13½-Ft. Wood-Stave Pipe*

The recently completed "Condit Plant" of the Northwestern Electric Co., of Portland, Ore., located about 70 miles east of Portland, while not conspicuous on account of size (20,000 hp.) and general character of equipment, yet has one feature of unusual interest—what is probably the largest wood-stave pipe yet built. There is a mile of this, 13½ ft. in diameter, serving as a flow line from dam to forebay.

The general layout of the power development is given by the accompanying map plan.†

LOOKING DOWN TOWARD FOREBAY LOOKING UP TOWARD DIVERSION DAM

THE 13½-FT. FLOW LINE OF THE NORTHWESTERN ELECTRIC CO.

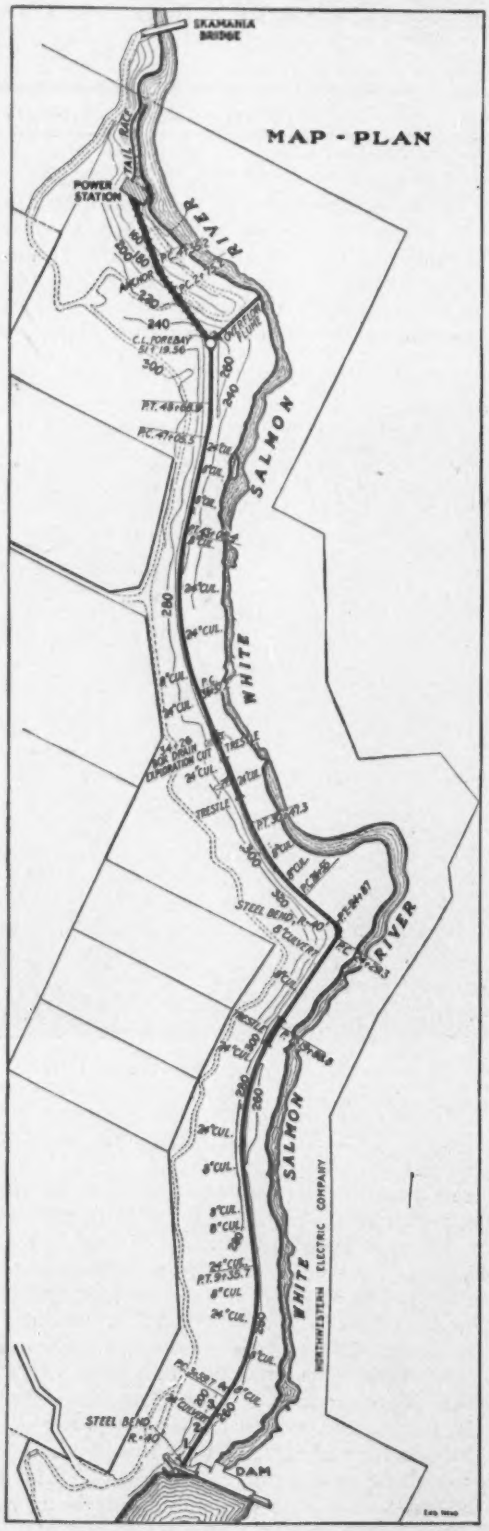
It is seen that the flow line runs along the edge of a gorge from the headworks on the eastern abutment of the dam. This pipe in elevation nearly traces a hydraulic gradient and runs full but under low head. It was designed by the Stone & Webster Engineering Corporation (general contractors for the detail design and construction), and B. C. Condit, chief engineer of the Northwestern Electric Co. The construction was sublet to the Pacific Coast Pipe Co., of Seattle.

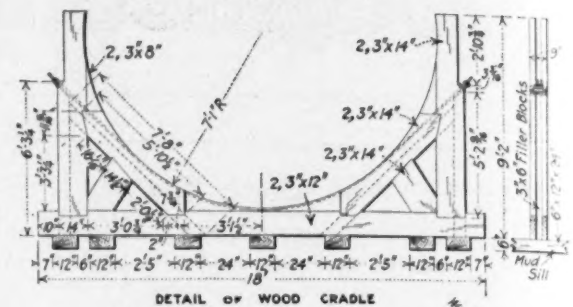
There are ninety-four 4-in. staves around the circumference, the lengths being normally 18 ft. Over 1600 M. ft. b.m. of No. 2 Douglas fir was used; 1000 in the pipe proper, 476 in the cradles, and 210 in the mud sills. This lumber was nearly all clear; it was kiln dried and planed with beveled edges, so that when fitted it naturally took circular shape. The material came from half a dozen mills, each being able to supply only a small part of the grade required; for the amount supplied, probably 3000 M. ft. b.m. of standard timber had to be cut, compared with a ratio of stave to total cut of one to six or seven prevailing in other parts of the state. The staves were laid without tongue or groove, there being a steel dowel plate in one end of each stave to make tight the butting joint. On account of the large diameter and small head, the pipe had to be braced against flattening. To this end the supporting cradles were spaced rather closely (4½ ft. apart on tangents and for the outer arc

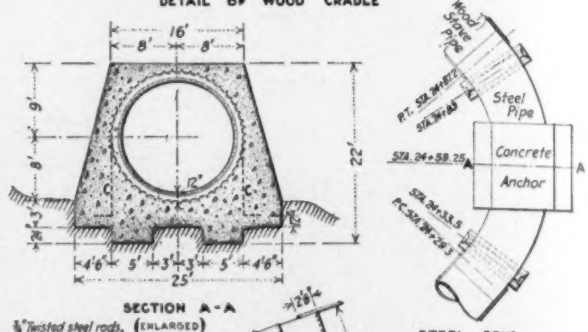
*From information furnished by the Stone & Webster Engineering Corporation, 147 Milk St., Boston, Mass.

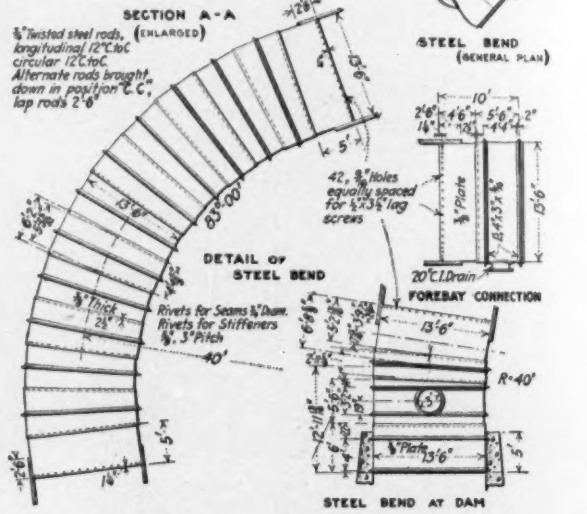
†There is a concrete gravity section dam, 125 ft. high and 471 ft. long, including the headworks. The spillway section is 232 ft. long, and 88 ft. thick at the base. The headworks comprise five 8x9-ft. (opening) wood gates with brass-bearing plates—operated by hand or machinery. There are screens and a trash sluiceway which carries débris from in front of the screens, over the dam. About 100 ft. below the crest are two 60-inch sluice gates, to wash out silt deposits; the valve stems run diagonally along the back face of the dam to the headworks. The crest is filled with flashboards designed to go out under a maximum flood of 20,000 sec.-ft. so as to leave a free way. The stream is subject to short periods of high water throughout the year, and to minimize the breakage, the flashboard pins have been designed to fail in groups, the middle section first, and then the west and east ends.

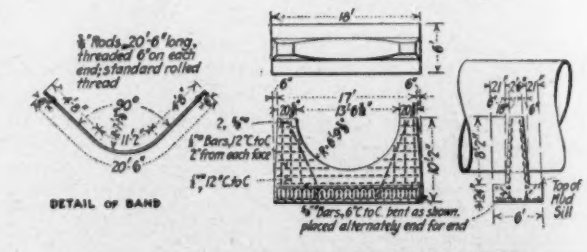
The power house itself is located directly on the river bank and secures a head of 177 ft. There are two main generating units, each comprising two 5000-hp. turbines on either side of a single generator. The discharge pipes have thrust bearings which in full normal operation carry no loads, but are capable of bearing the entire thrust of one turbine. It is claimed that, with this arrangement of wheels, the plant can be operated at high efficiency for ¼, ½, ¾ and full loads.

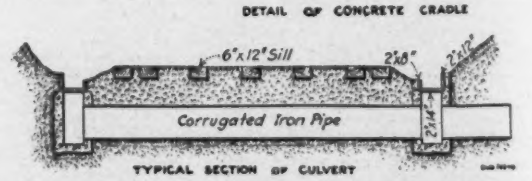












WHITE SALMON RIVER POWER DEVELOPMENT

of curves) giving three intermediate cradles between the end of the staves in addition to the supports at each end. The cradles were also carried well above the horizontal diameter, their arc spanning 200° angle as shown in the accompanying sheet of details. In making these cradles all joints were painted with white lead and oil. As the pipes thus rested on saddles carefully cut to shape, it was necessary to use a construction form and template only for the upper half (Fig. 4). The workmen engaged in this particular task had acquired a great knack of fast and workmanlike assembly of the staves, and laid an average of 80 lin. ft. per day for all weathers, frequently rising to 100 ft., and on one day to 180 ft.

Careful attention had to be given to proper support for the pipe, since when running full it weighs some four tons per foot length. The bed is all solid ground, except for a few short trestles, 130,000 cu.yd. of excavation having been required to give the desired gradient on firm bed.

Where sharp bends were necessary, steel-plate pipes were used, the general features of which are shown in the accompanying sheet of details. The wood and steel pipes have the same inside diameter, and the staves were lapped 30 in. over the steel, bands being placed as close as possible at joints. This construction gave a small flare to the staves and a tight joint was secured when the bands were cinched up.

The steel elbows and nipples have double-riveted lap joints and single-riveted girth joints. Where steel nipple or elbow joins wood pipe, the longitudinal seams are double-riveted butt joints, the butt straps being on the inside, flush riveted on the outside. The steel and wood lines are further held together at each joint by 42 lag screws sunk from the inside of the steel pipe.

At the forebay (a covered cylindrical concrete tank some 40 ft. in diameter) the water leaves the flow line and goes down 160 ft. to the power house in two 9-ft. wood-stave pressure pipes. These are 650 ft. in length, changing to steel sections near the power house.

The Gathmann Method of Producing Sound Steel Ingots

In a paper read before the British Iron and Steel Institute, at the September meeting in Brussels, E. Gathmann, of Baltimore, Md., described a method which he has devised for producing sound steel ingots. The principle of his method is to cause the ingot to chill and solidify progressively from the bottom upward, and to hold the upper portion or head longest in liquid condition. He claims that the result of applying this principle is sound steel, without blow-holes, requiring a discard of only 10% or less for the top pipe, and, what is equally important, less segregation in the steel. Test results support these claims.

In order to cause the ingot to solidify from the bottom upward, Mr. Gathmann uses an ingot mold having very thick walls in the bottom portion and thin walls in the part near the top. For crucible-steel ingots, he also brings the metal closer to the cooling influence of the walls in the lower portion by making the cross-section of the ingot narrower at the bottom than at the top, while retaining equal areas of cross-sections. Thus the section of the ingot at the bottom is rectangular and at the top square; a split mold is required, as the ingot cannot be drawn out endways. For openhearth work, where large ingots and solid molds are used, the ingot cannot be made with constant area of cross-section but must taper in the same direction on all faces, i.e., must be larger at one end than at the other. But while in usual practice the large end of the ingot is down, Mr. Gathmann casts with large end up, since the small end naturally cools faster than the large end. To promote still further the object of keeping the upper portion liquid last, he surrounds the thin-walled head portion of the ingot with a nonconducting mantle.

To get around the objection to ingots cast with large end up, that the usual practice for stripping is not applicable, Mr. Gathmann has designed a stripper adapted to handling these ingots with just as simple a procedure as that at present in use; several large steel plants are being equipped to carry out the method of stripping and handling ingots which he describes. The bottom of the ingot mold has a tapering hole, and this is closed by a taper plug projecting down a considerable distance below the bottom of the mold, passing through an opening cored in the stool plate. The stripper lifts the ingot mold and with it the ingot and the plug, and then, shifting over a short distance until the plug comes over the solid part of the stool, it lowers the mold, thereby forcing the plug up and forcing the ingot loose in the mold; then the ingot is lifted out by a soaking pit crane of ordinary form.

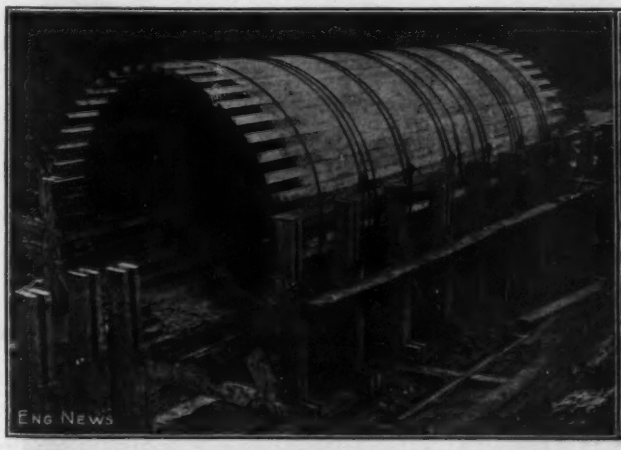


FIG. 3. TANGENT SECTION OF 13½-FT. WOOD-STAVE PIPE

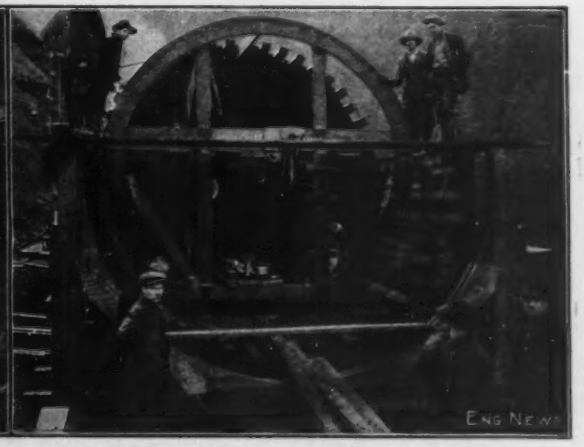


FIG. 4. CONSTRUCTION FORM AND TEMPLATE FOR 13½-FT. PIPE

Building a 1200-Volt Electric Railway

By Robert P. Woods*

SYNOPSIS—The chief engineer for the construction of the Kansas City, Clay County & St. Joseph Ry. gives a general review of the history of this interurban electric line, the problems of design and the more important details of construction, thus presenting in broad outline the engineering work on the development of a notable project.

The Project

The Kansas City, Clay County & St. Joseph Ry. is a 1200-volt, direct-current, catenary, high-speed, electric interurban road, radiating in two directions from Kansas City, Mo.; one division extending northeast 28.35 miles to Excelsior Springs, and the other northwest 52.42 miles to St. Joseph. The topography of the region traversed is generally rolling, with numerous places rough and hilly. The formation includes loam, earth, clay, loess or bluff clay and solid rock. Agriculture and stock raising are the principal occupations.

Many attempts have been made by various companies and individuals during the last twelve years to finance one or both of the two separate roads forming this project, but the absence of any suitable bridge, upon which to cross the Missouri River and adjoining low lands near Kansas City, prevented until the Armour and Swift packing companies and the Burlington railroad, which were joint owners of several thousand acres of land in North Kansas City, built a steel structure, on the more or less well known "Million Dollar Winner Piers," near the foot of Grand Ave., Kansas City, Mo. This bridge was opened for traffic Jan. 1, 1912.

Early in the summer of 1911, when it was apparent that the bridge would really be constructed, the interurban company was incorporated and a contract entered into with the bridge company, wherein it was agreed that the interurban company could operate its cars over the bridge and such track as the bridge company might build on its own land. At about the same time a contract was entered into, between the interurban company and the Metropolitan Street Railway Co., of Kansas City, Mo., whereby the latter agreed to supply to the former the current for operation of the interurban company's cars. Traffic contracts were also made, with the Metropolitan company, permitting the interurban company to operate upon 1.09 miles of the tracks of the former in Kansas City, Mo., and with the St. Joseph, Railway, Light, Heat & Power Co., allowing the interurban company to operate upon 2.16 miles of the former's tracks.

Kansas City holds an important commercial position among cities. It is one of the six largest food producing cities in this country and with one exception no other market in the world has more or larger packing houses, while as a grain center it is one of the three largest wheat markets and shipping points in the United States. It is known largely as a receiving and distributing point, to and from the Middle West. The aggregate population of Kansas City, Mo., and Kansas City, Kan., with the environs of both, is about 360,000. Of this about 260,000 should be credited to the former. The two cities really form one community, with the Kaw River separating them into separate municipalities. Excelsior Springs, well known as a health resort, has a fixed population of about 4000, and a transient addition of about 3000. Midway between it and Kansas City, is the agricultural section about Liberty, which has a population of 3000. The William Jewell College is located here. St. Joseph is a manufacturing and jobbing city, with a population of probably 80,000. Between it and Kansas City there is but one city or town, that of Dearborn with a population of 1000.

One of the principal factors entering into the location of the routes, was that of having the distance between the terminals on both divisions as short as possible, consistent

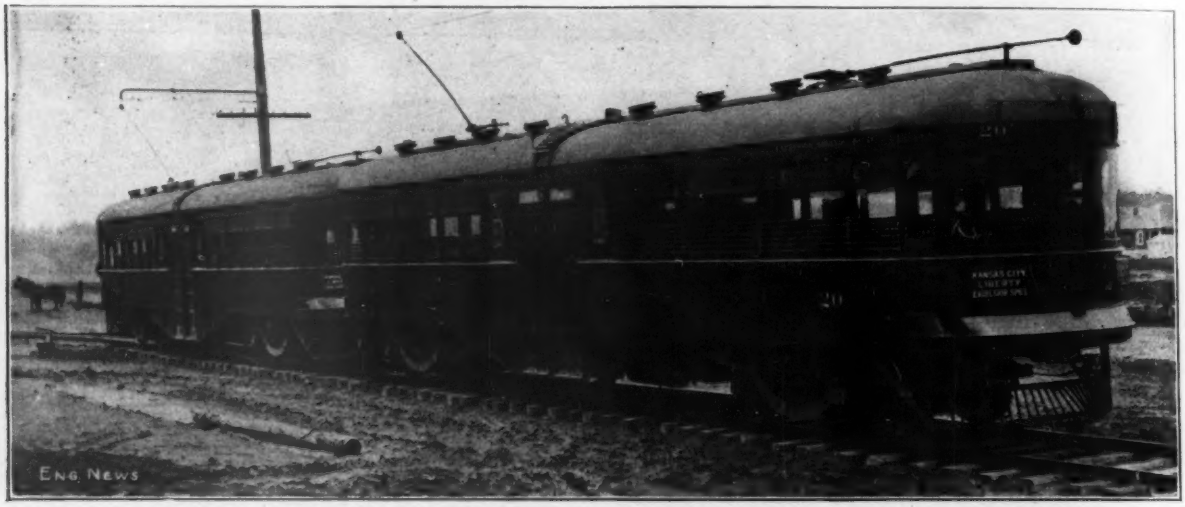


Fig. 1. Two-Car Train on the Kansas City, Clay County & St. Joseph Ry.

*Consulting Engineer, Indianapolis, Ind.

with reasonable expense. The result shows, that the distance on the electric line between terminals on the Excelsior Springs division, is 4⅔ miles shorter than that of the shortest steam line between its terminals; while on the St. Joseph Division, the electric line is 10½ miles shorter than its steam competitor, the Burlington road. The electric line has a further advantage in distance over its steam competitors on both divisions, because the interurban terminals in St. Joseph and Kansas City are both in the center of the shopping districts, whereas, those of the steam roads are not.

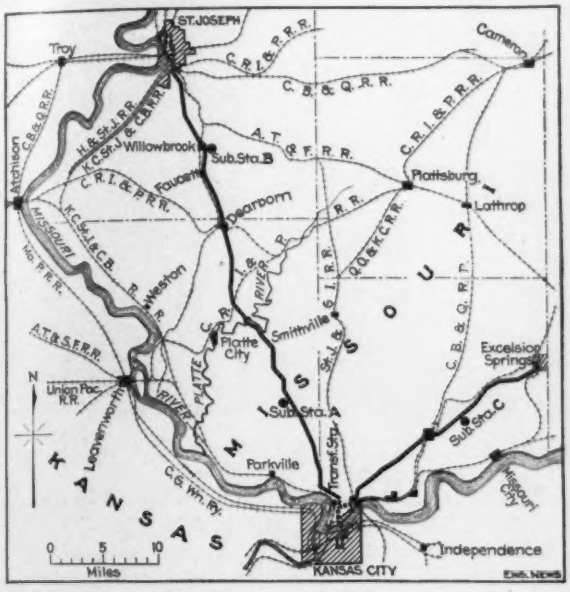


FIG. 2. SKETCH MAP OF THE KANSAS CITY, CLAY COUNTY & ST. JOSEPH RY.

Considering the usual and unusual drawbacks that built in a reasonably short space of time. The surveys for the location of the two divisions began July 1, 1911. Contracts were signed Sept. 8, 1911, covering the entire grading, and the work of grading began Sept. 22, on both divisions. The electric cars began regular passenger service over the Excelsior Springs division on Jan. 21, 1913, and on the St. Joseph division, May 5, 1913. From the beginning of grading, until the cars were in full and regular operation on both divisions, 19½ months had elapsed, while from the time the location surveys were begun, until the full operation, on both divisions, 22⅓ months intervened.

SERVICE—Owing to the newness of the road, the train schedules are not yet as fast as they will be later on. At present the local trains operate between terminals on the St. Joseph division, at an average speed, including stops, of 24⅛ mi. per hr., and 24⅓ mi. per hr. on the Excelsior Springs division. The limited service speed on the St. Joseph division is 27⅓ mi. per hr., and 31 mi. per hr. on the Springs division.

ROADBED

Private right-of-way was secured throughout (excepting in cities, where the road was built in streets) the width varying from 66 to 200 ft.

On account of the different kinds of soil formation encountered, five standard cross-sections for roadbed shapes were employed, as shown in Fig. 2. More than two million cubic yards of earth and rock were moved on the work. Embankments as high as 55 ft. and excavations as deep as 65 ft. were made; in the latter case, the cut was in solid rock, and was so made for the double purpose of reducing grade and supplying rock for ballast on the Springs division.

The road was ballasted with crushed limestone, about 2100 cu.yd. per mile being used, or an average depth of more than 6 in. under the ties. The ties are of standard-type white oak, 6x8 in. by 8 ft., 2640 per mile. Pine was used for bridge decking, and dimensioned white oak for switch timbers. Rails are 70-lb. Am. Soc. C. E. T-section for open track and 80-lb. Am. Soc. C. E. T-section in streets.

In determining the size of opening required for the many waterways, observations and measurements were made of each locality with reference to the area drained and the conditions affecting the speed of the water reaching the openings as well as measurements of existing is the obtained area. Variations were made in the value near-by openings. With such in hand, the following formula of Prof. Talbot's was used:

$$Opening = C \times (A^{\frac{1}{2}})$$

in which the value of C is taken as 0.8. A, of course, is the drainage area. Variations were made in the value of C depending on conditions. In general in steep and rocky ground C varied from 0.6 to 1.0; for rolling agricultural country, subject to floods with length of valley three or four times its width, 0.3 to 0.5.

To eliminate dangerous grade crossings, and in consequence to reduce the dangers and liabilities incident to operating the cars at grade across important highways and steam railroads, the interurban company at its own expense constructed steel or reinforced concrete structures, over or under 20 highways and seven steam roads.

The entire right-of-way is fenced with 10-bar woven-wire fence, topped with a barbed strand. The posts and braces are steel tubes, the former of No. 16 gage, 1 in. in diameter at the top and 2 in. at the base. The length is 7 ft., of which 29 in. is in the ground. The spacing is 16 ft. All corner and end posts are incased in concrete,

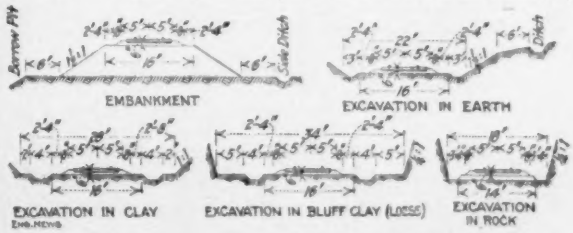


FIG. 3. STANDARD ROADBED SECTIONS; K. C., C. C. & ST. J. RY.

below ground. A hanging type of steel-pipe gate, 16 ft. long, has been installed.

All highway grade crossings have wooden cattle guards with two panels of board fence on either side of the guards. The balance of the approach fence is of wire. Four planks are placed next to the rails at all road crossings; at the public crossings they are 16 ft. in length and 12 ft. at farm crossings.

A standard railroad crossing sign is placed at every public crossing, and 1100 ft. distant either way on the railway is a whistle sign showing a large "W."

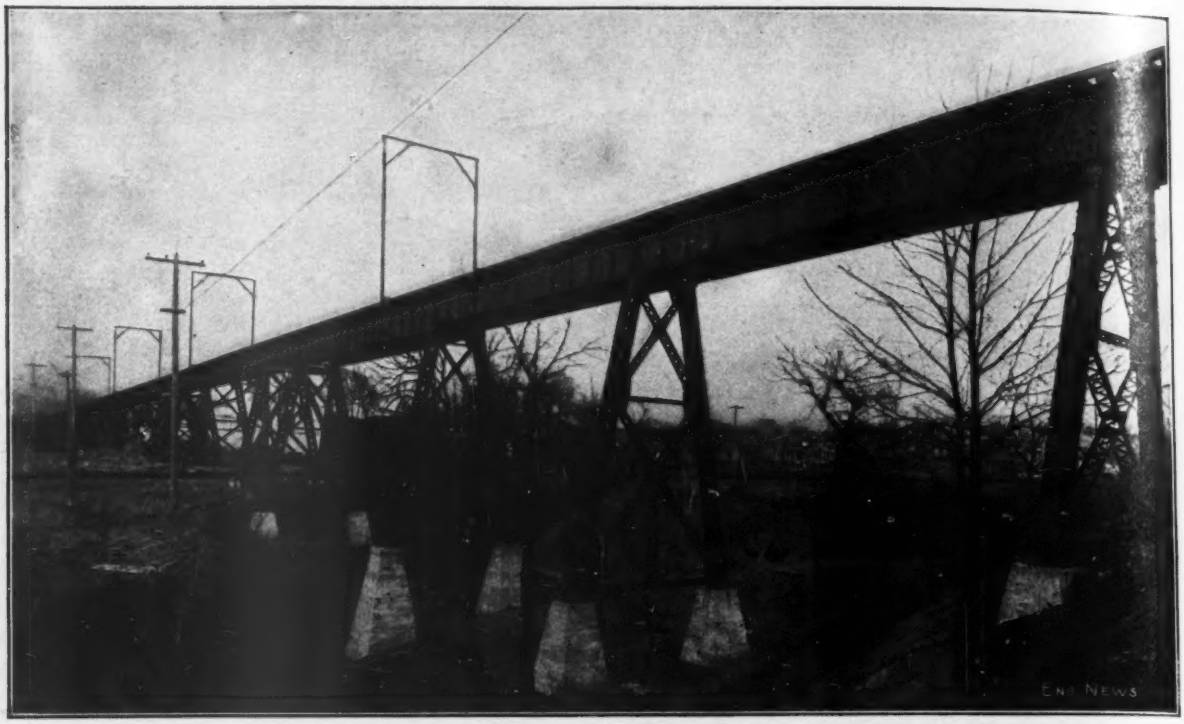


FIG. 4. DEARBORN VIADUCT, ST. JOSEPH DIVISION; K. C., C. C. & ST. J. RY.

At present no automatic signal system has been installed, but at one questionably safe grade crossing, a bell annunciator has been located.

BRIDGES

Concrete substructures and steel superstructures were built for the two 160-ft. spans over the Platte River, and wherever viaducts were needed. All other roadbed structures were of reinforced concrete. Culverts above 3 ft. in diameter were arches; below that they were of circular pipe with concrete bulkheads. There were seven steel structures, two of which were 1100 and 700 ft. long respectively. The reinforced arches number 110, and all are of the Luten type; several are of three spans with lengths of 200 ft. The live-load assumed on all bridge structures is that of 100-ton electric locomotives coupled together. Each locomotive was assumed to have four axle loads of 25 tons each, with axles spaced in order, 6 ft., 19 ft., 6 ft., 14 ft., 6 ft., 19 ft., 6 ft., etc.

Bids were received on reinforced arch and beam structures for each structure complete as per data furnished bidders. Inasmuch as the grades of the roadbed were likely to be changed in places, due primarily to the haste in adopting grades that the grading work might get under way, and in consequence, changes would be made in the dimensions of some of the arches, the following cost formula was evolved from the accepted bid and it was used in computing the cost of such arches as were altered in size.

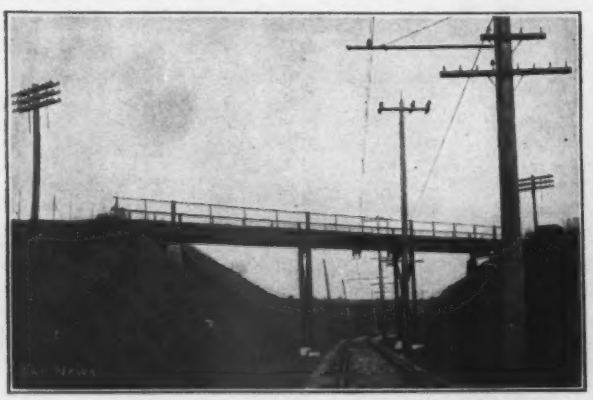


FIG. 5. STANDARD WAGON ROAD OVERWAY; K. C., C. C. & ST. J. RY.

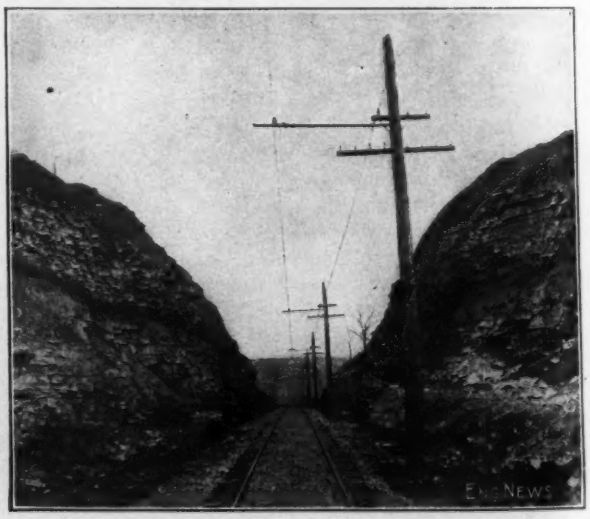


FIG. 6. 65-FT. CUT IN BALLAST ROCK; K. C., C. C. & ST. J. RY.

$$(S + 2)\ (3F + W + 10)\ I = Price$$

S = Span in feet;

F = Profile fill from sub-grade to bottom of ditch in feet;

W = Sub-grade width in feet;

10 is index to Index;

I = Index = Unity for following prices:

Cement, per bbl.	$1.25
Sand, per yd.	1.00
Stone, per yd.	1.00
Lumber, per hundred feet	2.00
Steel, per hundredweight	1.75
Labor, per day	2.00
Excavation, per yd.	0.50
Superintendence, per hour	0.50
10	10.00
Index	1.00

The line of road was divided into a dozen or more different zones, and the costs for the materials and labor in each estimated, to enable fixed values to be determined for Index I, for the different arch sites. These values for I varied from 1.30 to 1.70. Where additional foundations were added to those shown on plans, additional compensation was allowed at a stated price, per yard of concrete, and lineal foot of pile.

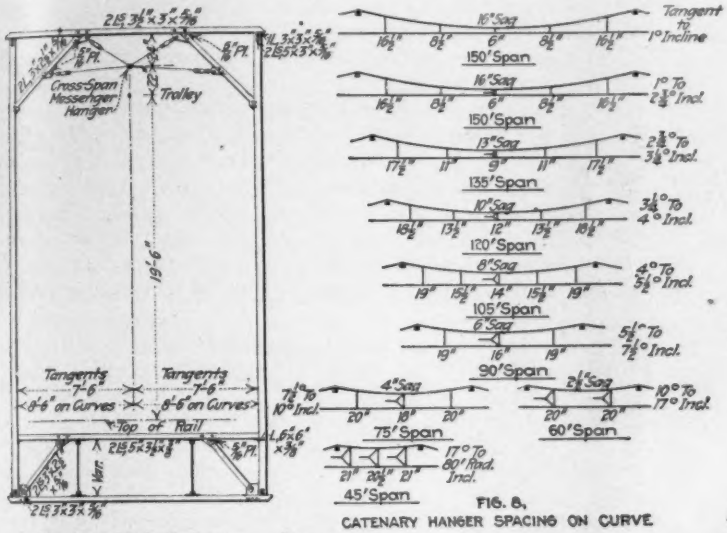


FIG. 8, CATENARY HANGER SPACING ON CURVE

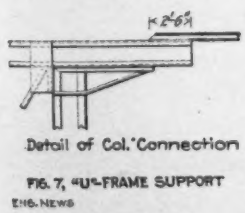


FIG. 7, "U"-FRAME SUPPORT

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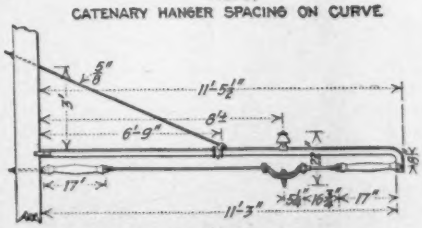

FIG. 10, DETAIL OF 2½" × 2½" × 5/16" T-IRON BRACKET

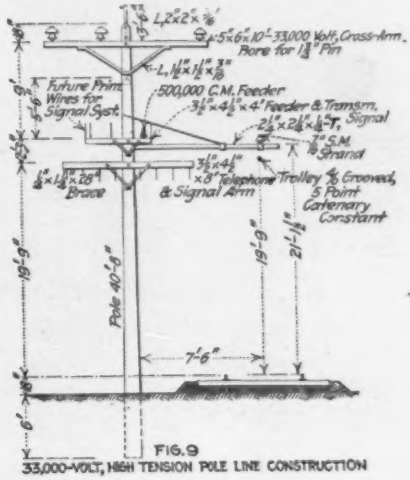

FIG. 9 33,000-VOLT, HIGH TENSION POLE LINE CONSTRUCTION

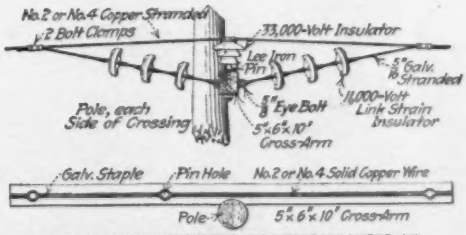
No. 2 or No. 4 Copper Stranded
2 Bolt Clamps
33,000-Volt Insulator
Lee Iron Pin
Pole, each Side of Crossing
⅝" Eye Bolt
11,000-Volt Link Strain Insulator
5" × 6" × 10' Cross-Arm
Galv. Staple
Pin Hole
No. 2 or No. 4 Solid Copper Wire
Pole
5" × 6" × 10' Cross-Arm

FIG. 11, METHOD OF ANCHORING HIGH-TENSION WIRES AT TELEPHONE CROSSING

Power Distribution

Electric current for the operation of the road is purchased from the Metropolitan Street Ry., of Kansas City, Mo. Three-phase, 25-cycle current is delivered to the interurban company at the Metropolitan power station in Kansas City, at 6600 volts and is taken on three 300,000-circ.mil. bare copper wires, across the river bridge to the interurban company's step-up transformer station, 2½ miles distant in North Kansas City, Mo.

The transformer station contains three 750-kv.-a., single-phase 6600/33,000-volt, oil-cooled transformers and one 5-kv.-a. transformer, single-phase, 6600/220/110 volts; a one-panel switchboard and accessories. For supplying the St. Joseph division, the high-tension current is carried from the transformer station at 33,000 volts, northwest along the road, on three No. 2 bare copper wires. At 11.82 miles out is substation "A," where there are two 500-kw. rotary converters, three-phase, 750-r.p.m., 1200-volt (direct current). The rotaries are arranged for 1500-volt operation, should they be so needed in the future. From substation "A" the 33,000-volt current continues along the road northwest on three No. 4 copper wires, 26.44 miles to substation "B," located at Willow Brook, where there is the same electrical apparatus as in substation "A." Substation *C* is located on the Springs division 15¼ miles northeastwardly from the transformer station and has an equipment similar to the other two substations. Three No. 4 wires carry 33,000-volt current.

The transmission line to the transformer station is designed to carry 2250 kw. over the 2.50 miles with a drop of 2.9 volts and a loss of 82.2 kw. or 3.65%. The 11.82 miles of line to Substation A (1000-kw. capacity) is designed to carry 2000 kw. with a drop of 990 volts and a loss of 66 kw. or 3.3% loss. Of the energy transmitted to this point 1000 kw. is intended to go to Substation B and the 26.44 miles of line gives 1860 volts drop and 62 kw. loss or 6.2%. The other branch line of 15.29 miles from the transformer station to Substation C is designed to carry 1000 kw. with 1125 volts drop and 37.5 kw. loss or 3.75%.

The 1200-volt direct-current feeder and distribution on the St. Joseph division extends 8.43 miles beyond substation "B" at Willow Brook, to St. Joseph. On the springs division, it extends ten miles beyond substation

"C" to Excelsior Springs. This feeder system runs the entire length of the road with one 500,000-circ.mil. stranded bare copper wire, one No. 0000 grooved copper trolley, and one $\frac{7}{8}$-in. S. M. galvanized stranded-steel, catenary messenger wire. The feed taps from the feed wire to the trolley are No. 0 insulated stranded copper wire and average three to the mile.

There are two No. 10 copper telephone wires the length of the line, with five transpositions per mile. Tele-

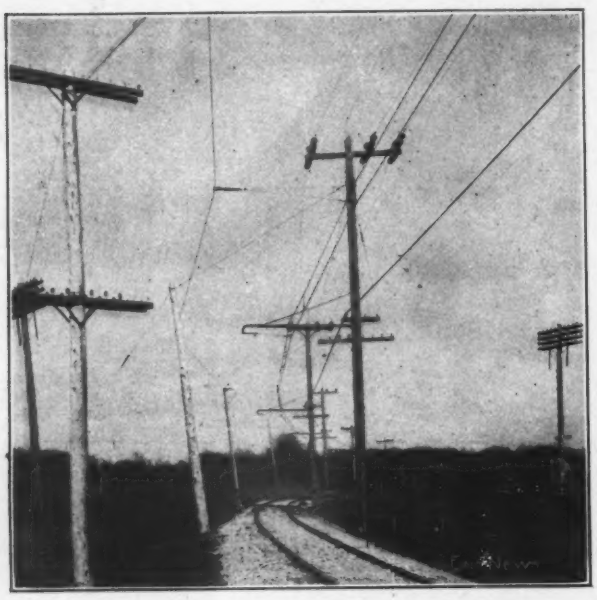

FIG. 12. CATENARY CURVE CONSTRUCTION AT HIGHWAY NEAR LIBERTY, MO.

phone connections are placed one mile apart on the pole line. Trains are dispatched by telephone.

A No. 6 galvanized-steel wire is strung over the tops of all high-tension poles, 22 in. above the top of poles, and 42 in. above the top of the high-tension crossarm, on a porcelain knob fastened to an angle-iron bayonet. This wire is grounded five times per mile with No. 8 galvanized wire. Garton-Daniels 1200-volt, direct-current lightning arresters have been placed on the feeder system, a fifth of a mile apart.

The track bonds are No. 0000 flexible copper with terminals $\frac{7}{8}$ in. in diameter and 10 in. apart.

The trolley line is a single, five-point catenary, bracket type, operating on 1200-volt direct current, though at turnouts, bridges, and in streets, span construction was employed. The poles are Michigan white cedar, 40 ft. in length where carrying a transmission line and 35 ft. where without; the diameter at top is 8 in. The poles are spaced 150 ft. apart on tangents, and on curves the spacing is variable, depending on the degree of curvature, and was such that the maximum variation in position of the trolley wire with respect to the center of track did not exceed 6 in. The spacing with 12-ft. brackets was: 1° to 2.75°, 150 ft.; 2.75° to 3.25°, 135 ft.; 3.25° to 4°, 120 ft; 4° to 5.5°, 105 ft.; 5.5° to 7.5°, 90 ft.; 7.5° to 10°, 75 ft.; 10° to 17°, 60 ft.; 17° to 80-ft. radius, 45 ft. The sag from center of messenger to center is 22 in. at the mast arm, at 60° F.

The crossarms are of Washington fir, unpainted; 5x6 in.x10-ft., four-pin, were used for the high-tension wires; 3½x4½-in.x4-ft. three pins, for the feeder, and 3½x4½-in.x8-ft. eight pins, for the telephone wires.

Inverted U-frames built of steel angles were erected on the steel viaducts and supported the distribution wires. The bracket arms on tangent lines are 9-ft. 2¼x2¼x¼-in. T-iron with a ⅝-in. tension rod; the bracket arms for curves are similar other than their length is 12 ft., and thickness $\frac{5}{16}$ in. All insulators except those used for guying, are brown porcelain, and of capacity above their respective requirements.

BUILDINGS

The transformer station, substation, car house and shops, as well as the depots at Excelsior Springs and Liberty and the freight stations at Kansas City and St. Joseph are all of brick and concrete. The small waiting and shelter stations along the road are, with a few exceptions, of wood.

The car shops and storage compartments are located in a fireproof building in North Kansas City, Mo. This building is constructed of brick with steel roof trusses and reinforced-concrete roof of sawtooth type, and furnished with metal doors and window sash. The building is divided longitudinally into two parts by a brick wall; on the west side of the wall is the car storage, 191x53 ft., and on the north side are the car shops, 191x49 ft.

There are four tracks running full length in the storage section, which provide the storage for 12 passenger cars. The south half of this room has a cement floor. All the tracks are raised above the floor 18 in. on small concrete pedestals, to facilitate the inspection of trucks. There are two tracks in the car shops with capacity for five cars. The west end of the shop is depressed about 5 ft. below the main floor line and permits work to be performed under two passenger cars at one time. On this pit floor is located the blacksmith's outfit. All of the

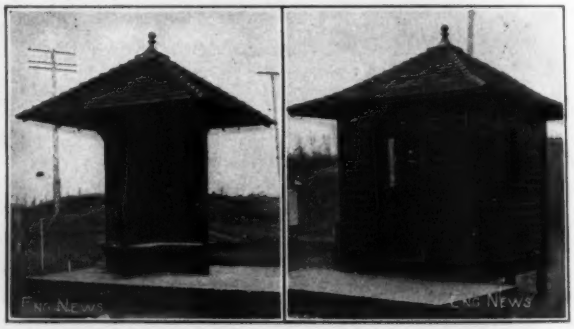

FIG. 13. TWO SMALL STATIONS ON THE K. C., C. C. & ST. J. RY.

shop floors are of concrete. Small supplies are kept in the north end of the shops, and a paint shop or oven, in which a car can be kept, is located in the northwest corner of the shops. The entire building is heated by a steam vacuum system. Fifteen feet east from the northeast corner of the shops is a brick oil house. Adjoining the east wall of the shops and at the south end are reinforced concrete and brick compartments for coal storage, while north of these are small offices for the master mechanic.

Cars*

The company has 16 all-steel, passenger, center-vestibule cars. Eight of these have two compartments, a regular passenger and a smoking section; the remaining eight cars have a general compartment, smoking compartment and baggage room. All cars have double-end

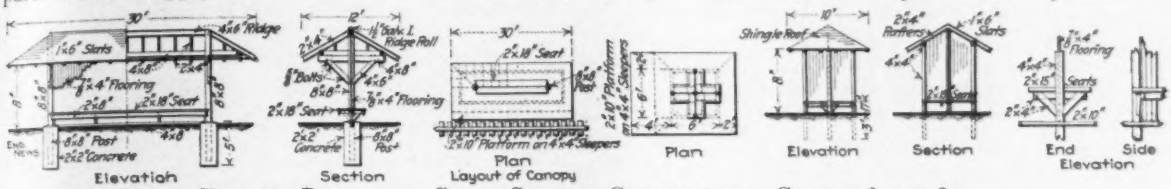

Fig. 14. Details of Small-Station Construction, Classes 2 and 3

electrical control, but ordinarily run with smoking or baggage compartment in the rear. The cars are so constructed that they can operate regularly at a speed of 60 mi. per hr. without excessive vibration and are thoroughly braced and stiffened to withstand the strain and shocks due to operating at a high rate of speed. The cars are equipped with four 100-hp., 1200-volt interpole motors, arranged for multiple-unit control. Trains of three cars have been operated successfully. The length of the car is 58 ft. over bumpers, the width over all is 9 ft. The seating capacity is for 64. Total weight of car is 81,000 lb.; distance between truck centers, 35 ft. There are five double-end, all-steel express cars having a carrying capacity of 25,000 lb. These cars have similar electrical equipment to those on the passenger cars, and are arranged for the same speeds; length over bumpers 52 ft. 4 in.; distance between truck centers 29 ft. 4 in. There are five wooden freight trailer cars, length over bumpers, 42 ft. 6 in., distance between trucks, 30 ft. 6 in.

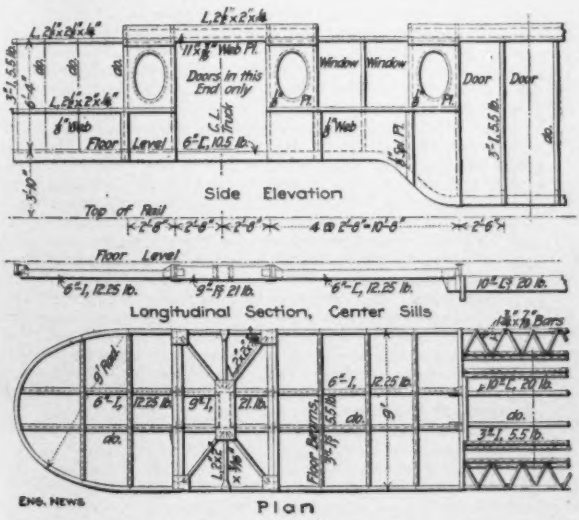

Fig. 15. Steel Frame Construction for High-Speed Passenger Car

The one steel work car is equipped with four motors similar to those on the passenger cars. It is 52 ft. 4 in. in length over bumpers, and has a carrying capacity of 25,000 lb.

*Notes on the electrical equipment contributed by W. D. Bearce, Railway and Traction Engineering Department, General Electric Co., Schenectady, N. Y.

The electrical equipment is designed for 1200-volt operation with a possibility of raising the trolley potential to 1500 volts at some future time. Each car is equipped with four box-type, commutating-pole motors having an hourly rating of 125 hp. at 750 volts. The motors are totally inclosed and internally ventilated by means of a centrifugal fan made integral with the pinion-end armature head. This fan circulates the air through longitudinal holes in the armature and over the surface of the armature and field coils, thus securing a practically uniform temperature throughout the motor and a greatly increased service capacity. The motors are permanently connected two in series for operation on 1200 volts, and

Fig. 16. 225-Hp., 600-750-Volt, Commutating-Pole Fan-Ventilated Railway Motor. (Two in Series Used on 1200 Volts)

consequently will operate at half speed on a 600-volt city line. The weight of the motor complete with gear, pinion, gear case and axle linings is approximately 3860 lb.

The control is of the multiple-unit relay automatic type, arranged to give bridge connections, during the transition from the series to the parallel points. The 14 contactors which operate the various motor circuits and resistance combinations are contained in a grounded metal box mounted underneath the car.

The control and lighting circuits are supplied with 600-volt current from a dynamotor, when running on the 1200-volt trolley, and direct from the trolley wire on 600 volts. A selector relay, operated from the motorman's cab, is used to transfer these circuits from the dynamotor to the trolley circuit when the car passes from a 600- to a 1200-volt section, or *vice versa*. This relay has a gravity position for operating on 1200 volts and a second position when the coil is energized for operating on 600 volts. To prevent injury to the low-voltage circuits by closing this switch while on the 1200-volt section, or by leaving it closed when running from a 600-volt to a 1200-volt section, a protective relay is used. This device consists of two coils connected in series with each other and a suitable resistance across the line. One coil is designed to pick up its armature at approximately 800 volts and this action short circuits the

second coil. The second coil operates at approximately 250 volts, and is provided with a dash pot to give it a delayed action. When low voltage is impressed on the relay, the low-voltage coil picks up and soon closes contacts which operate the selector relay, bringing it into position for 600-volt operation. If a high voltage is impressed on the protective relay, the high-voltage coil at once picks up, short circuiting the sluggish low-voltage coil and preventing it from closing. The selector relay then remains in the gravity position for 1200-volt operation.

These cars are also provided with an emergency electric-braking feature which can be used in case of failure of the air brakes. Since two motors are connected permanently in series, the desired braking effect cannot be secured by simply throwing the reverser, as is the case when the motors are connected for parallel operation. A special air-operated switch is therefore provided for connecting the two sets of motors in parallel; this switch is held in the emergency-braking position by air pressure and returned to the operating position by a heavy spring,

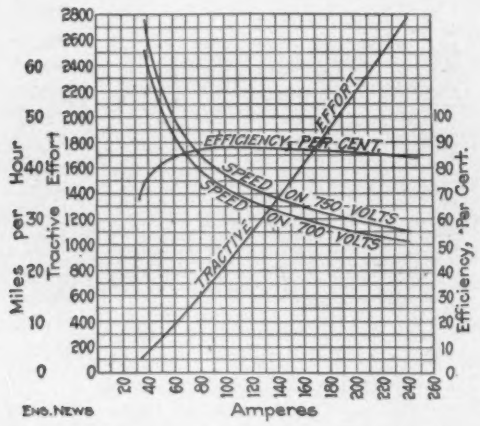

FIG. 17. CHARACTERISTIC CURVES OF 225-HP., 600-750-VOLT, COMMUTATING-POLE FAN-VENTILATED RAILWAY MOTOR

as soon as the air pressure is released. The reverser is also provided with air cylinders. In case of emergency the motorman opens a cutout cock, and air from a special auxiliary reservoir (which is cut off from the main reservoir by a check valve), passes to the proper cylinder on the reverser throwing it into reverse position for braking. As the piston in the reverser cylinder moves, it uncovers a port and air then passes to the cylinder on the paralleling switch throwing this also into the braking position. When the air pressure is released, this switch returns to normal position, breaking the arc on its fingers, which are provided with magnetic blowouts. The reverser is thus relieved of breaking the motor circuits.

The air brakes are of the combined straight and automatic type consisting of an automatic variable-release brake with the straight-air feature added. This equipment provides for straight-air operation on single cars and an automatic application and variable release for train service. Both the straight and automatic application of air is made from a single motorman's valve by simply moving the valve handle to different positions on the valve quadrant.

Luminous-arc headlights are used, each with a semaphore lens throwing a long, narrow beam to a distance of 2000 ft.

All cars are equipped with rolled-steel wheels, 33 in. in diameter, with a tread 3½ in. and a depth of flange of ⅞ in. The thickness of flange is 1 3/16 in. and the thickness of rim is 2½ in.

The cars were made by the Cincinnati Car Co., with motor and control equipment from the General Electric Co. The power generation and substation equipment was built by the Westinghouse Electric & Manufacturing Co.

The syndicate managers of the project were Tucker, Anthony & Co., of Boston and New York, acting for themselves and the National City Bank of New York, as joint bankers. The Executive Committee directing the work, was composed of Chauncey Eldridge, of the firm of Tucker, Anthony & Co., C. C. Chappelle, of the Federal Light & Traction Co., of New York, and Thos. A. Reynolds, of the National City Bank, of New York. The writer represented them on the work, as chief engineer in charge of construction. The promoters and general contractors were Geo. Townsend, W. E. Kirkpatrick and Ward S. Arnold, of Chicago. The general manager of operation is J. R. Harrigan.

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Studies in Street Lighting at Washington, D. C., were discussed in a paper by W. C. Allen, Electrical Engineer of the District of Columbia, read before the City Club of Chicago recently. To formulate a definite plan for lighting improvement, in 1910 experimental installations were made on two very wide streets. Temporary wooden posts were erected and equipped so that the lamps could be raised or lowered. Various sizes of lamps and kinds of globes were tried, but finally it was decided that lines of 100-cp. tungsten-filament incandescent lamps in opalescent globes on posts 120 ft. apart (but staggered on opposite sides of the street giving a lamp each 60 ft.) were the most satisfactory. This produces a very uniform illumination, but of low intensity. When more light is desired the same posts and lamps are placed 75 ft. apart and directly opposite each other on the two sides of the street. One of the principal factors determining this choice was the park-like character of the streets. Only two important business streets, each about 3000 ft. long, have no trees, besides some without trees for a few blocks. On one of these long streets (7th St.) 100-cp. lamps were placed 75 ft. apart on both sides of the street; one-third of the cost of the scheme being paid by the merchants. The lamps are connected by cables laid about 8 in. underground and immediately back of the curb line. At first, multiple cables with steel armor were used but, owing to difficulties in making connections at the post bases, a single conductor cable with varnished cambric insulation and a ⅛-in. lead sheath was employed, having an additional protection (a wood strip) against blows from excavating tools. Tile duct is laid across intersecting streets or alley entrances to carry the cable. Lamps on one side of the street are on a separate circuit than those on the other side. The installation cost per lamp was approximately $45 including cable, fittings and labor, but excluding cost of globe and post. The yearly maintenance cost at established rates is $30 per lamp.

After extended experiments, arc lamps have been selected for the improved lighting of Pennsylvania Ave. This avenue, stretching from the Capitol to the Treasury Building, a distance of over 6000 ft., has a width of 110 ft. between curbs with numerous open places and triangular parks. A 6.6-amp. luminous arc is to be placed on top of a post in a spherical ribbed-metal frame holding segments of opalescent glass. The lamps on Pennsylvania Ave. are to be 100 ft. apart at each curb, with lamps on opposite sides staggered. The cost complete will be about $70 and the maintenance cost will be $92.10 per year. The same system may be extended further to the business district, using, however, a 4-amp. type.

The plaza in front of the Union Station, which is about 500x800 ft., also requires special treatment. The outer roadway of the plaza will be lighted with luminous-arcs suspended from 22-ft. posts. At islands scattered over the plaza will be 6.6-amp. magnetite arcs in 24-in. metal frames with opalescent glass colored to give a yellow tint to the light.

Thermal Testing Plant at the Pennsylvania State College*

By J. A. Moyer†

The Pennsylvania State College has established and equipped the largest and most elaborate thermal testing plant in America. The complete equipment was secured less than a year ago, but during the short time the plant has been operating some very interesting results have been obtained.

Heretofore nearly all testing of materials of construction to determine the rate of heat transmission, particularly at low temperatures, has been by the method of melting a known weight of ice in a comparatively small box constructed of the material to be tested. The rate of heat transmission for such tests was then calculated from the weight and latent heat of the amount of ice melted in a given time. Such tests were always made with only such natural circulation as might occur in the inside and on the outside of the box.

This method is unsatisfactory because it is difficult to get the accurate weight of ice (without water) at the exact times of beginning and ending the tests, and it is difficult to make the proper correction for the temperature of the water coming from melted ice. Samples used in this method must be either very much too small to get accurate results, or else with a larger sample the circulation must necessarily be different from the conditions in a cold-storage plant.

The methods that have been used for obtaining the temperatures have also varied, and in many tests the methods of obtaining the temperatures as regards the nearness to the walls is not stated. With the location of thermometers uncertain and with no information regarding the air velocities and humidity, it is not surprising that different observers do not agree as to the heat conductivity of insulating materials used in cold-storage plant construction.

The method of measuring the transmission by the melting of ice on a single slab or sheet of the material is also in error for similar reasons, and has the further disadvantage that proper allowances cannot be made for the exposed perimeter. There is no known method of calculating such an effect.

In the thermal testing plant of the Pennsylvania State College, every effort has been made to eliminate these difficulties. The calorimeter is roomy, so that large samples can be tested. The means are also available for measuring and varying the velocity of the air. By means of accurate and delicate platinum resistance thermometers located in the calorimeter room, at the inside and outside walls of the material being tested, as well as on the surfaces and imbedded at various distances in the body of the material, it is believed very accurate determinations can be made.

This plant consists of two separate brick buildings. One is 50x18 ft. and houses a complete 10-ton experimental refrigeration plant; the other is the testing-plant proper, 32x32 ft. on the outside, and contains the calorimeter room, 17x17 ft. This room is cooled to low temperatures by a number of rows of brine coils encircling the room. Cold brine is supplied from the refrigerating plant in the adjacent building through 2-in. heavily insulated pipes.

The material to be tested is made up into a cubical box of approximately 150 sq.ft. of outside surface; and this box is then suspended in the calorimeter room for testing. An electric fan and an electric heating coil are placed inside the box for producing the required uniformly distributed temperature difference between the inside and the outside of the box. By this method tests can be made for a very great range of temperature differences. Constant and uniform temperatures can be maintained for an indefinite period of time, and the method of measuring the heat put into the box per unit of time is measured by calibrated voltmeters and ammeters on both the coil and the fan circuits.

Platinum resistance thermometers made to special designs for this work are available for measuring the temperatures, inside and outside the test-box as well as its walls. Cylindrical platinum coils are used for measuring the temperatures in all places except on the surfaces of the material, where thin platinum resistance disks less than $^1/_{30}$ in. thick are firmly attached to the surface on their flat sides. Adopting the method of the U. S. Bureau of Standards the temperatures have been observed in each test in the following locations: (1) 2 ft. from the surface of the material tested, inside and outside; (2) 1 in. from the surface, inside and outside; (3) on the inside and outside surfaces by absolutely close contact; (4) at every inch of thickness through the material, also with thin, flat platinum resistances which can be accurately located. Air velocities outside the test-box were varied by the use of six variable-speed ventilating fans.

There should be some standard for the locations at which temperature differences are to be measured, as well as standards of air velocity and humidity. Still air is most unsatisfactory; the best reason being that it is unobtainable. Wherever there is heat transfer there is air circulation. The so called "still-air" determinations mean merely that air velocity is not uniform. With so called "still air" one can get all sorts of results with the same apparatus. It can be satisfactory only if one can observe simultaneously temperatures in an apparatus at a hundred or more different places.

A test of a cork-board cube shows that the transmission is increased about 34% as the velocity of the air (over the outside of the box) is varied from 222 ft. per minute to 905 ft. per min., or the transmission is changed 5% per 100 ft. per min. change in velocity. In all these tests the velocity of the air inside the box was approximately 200 ft. per min. Velocities were measured with a carefully calibrated anemometer.

Tests made to show the change of transmission with variation in humidity show that by increasing the humidity from 70 to 90%, the transmission is increased 2.4%, which is equivalent to a change of 1.2% in transmission for a variation of 10% in humidity. The velocity of the air outside the box was 900 ft. per min.

The accompanying table gives a number of values of heat transmission as determined in the plant described. The temperatures were observed at 1 in. from the inside and outside walls, and the velocities were in all cases about 200 ft. per min. Humidity was about 80%.

TABLE OF UNIT HEAT TRANSMISSIONS

B.t.u. per sq.ft. per hr. per deg. F. difference.

1 in. common brick	4.66
One 4-in. hollow tile	.625
1 in. concrete (1-3-5 mix)	4.29
⅞-in. lumber (T and G)	.83
One air space (from 1 in. to 6 in.)	1.66
1 in. mineral wool (dry)	.666
1 in. building paper	.20
1 in. pitch	.79
1 in. shavings (dry)	.666
1 in. granulated cork	.479
1 in. hair felt	.31
1 in. indurated fiber board	.416
1 in. compressed mineral wood board	.33
Single window (all glass)	1.09

*Abstract of a paper presented at the International Congress of Refrigeration, at Chicago, Sept. 17-24.

†Professor in Charge of Pennsylvania Experimental Station, Pennsylvania State College.

A Brick Pavement Left Intact over a Washout

An interesting instance of a brick paving remaining in place after the supporting ground beneath it had been removed was shown during the recent convention of the National Paving Brick Manufacturers' Association in Cleveland, Ohio. An 80-ft. section of Dunham Road, in Cuyahoga County, was washed out by a recent flood in Tinker's Creek. The road was covered with a grout-filled brick pavement laid on a sand cushion over a 4-in. concrete base. At one point the road embankment was washed away, and the concrete base dropped for about half the width of the brick above. The brick, however, arched over the opening and held its own weight and even the weight of an automobile as shown in the photograph.

Brick Pavement Left Intact over Washout

Dunham Road at Tinker's Creek, Cuyahoga County, Ohio.

The Cast-Steel Dome for the Drainage Shaft of the Hudson River Siphon, Catskill Aqueduct

In the tunnel under the Hudson River for the new Catskill Aqueduct, New York City, the construction shafts on each side of the river leading to the tunnel 1100 ft. below are to be used as the vertical parts of the finished siphon. On the western side of the river the water enters the shaft from the Moodna siphon, and on the eastern side it emerges into the Breakneck siphon, having a head of 410 ft. from the surface of the river to hydraulic gradient (at the latter juncture). In the final construction the western shaft is to be closed with a large concrete plug just above the upper siphon entrance, but the eastern shaft is to be utilized as a drainage and inspection shaft for the siphon and for that reason had to be closed with some removable top capable of safely holding the 410-ft. head there.

As at the access shaft of Moodna siphon, the closure is being made by a cast-steel dome fitted across the shaft at its top and held in place against the pressure by anchor bolts reaching down to an anchor ring embedded in the concrete lining of the shaft. The Hudson shaft dome, however, is much larger than the Moodna, which is 8 ft. in diameter.

The riser shaft is in solid rock and is lined with concrete so as to give an interior diameter of 14 ft., this diameter being required to carry the necessary amount of water through the aqueduct. All pressure tunnels of the Catskill Aqueduct are to be emptied through drainage shafts by pumps which are to be installed as required from time to time in cylindrical steel floats. The float will be held in place by reinforced-concrete guides built monolithically in the side of the shaft. While each shaft has its individual float, the pumping outfit used in the various shafts is the same, and it was found impossible to compress this plant into an area smaller than the circle of 14-ft. diameter. For this reason it became necessary to make the dome the full diameter of the shaft. In fact, the engineers would have liked to have had a larger area for their pump setting.

Fig. 1 shows the general location of the dome in the shaft and Fig. 2 the details of the dome and its anchorage. It will be noted that the dome is located about 15 ft. below the floor of the shaft headhouse, which is itself some 25 ft. above the level of the Hudson alongside, about 1175 ft. above the Hudson siphon level, and about 245 ft. above the Breakneck siphon level. The shaft to El.—175, has, in addition to the regular concrete lining a steel interlining made up of a cylinder of ⅜-in. steel extending down to a point where it was considered that the rock, with the concrete lining and grouting, would offer sufficient resistance to the percolation of water.

The dome is a segment of a hollow sphere 15 ft. in interior diameter, 16 ft. 11 in. in exterior diameter at the base, and with an interior rise of 6 ft. It is 3 in. thick at the crown where a manhole is located and about 8 in. thick at the base. The dome rests on a cast-steel curb ring and is held in place against this curb ring by 36 circumferentially placed bolts extending 50 ft. down into a cast-steel ring, also embedded in the concrete lining. The steel interlining noted above is tap screwed into the curb ring and the anchor ring, as noted in Fig. 2. Each 4½-in. anchor bolt, of nickel-chrome steel, [illegible]nds through the base of the dome and the curb ring to the anchor ring and is incased with a steel sleeve on which have been cast protruding rings to give the sleeve a bet-

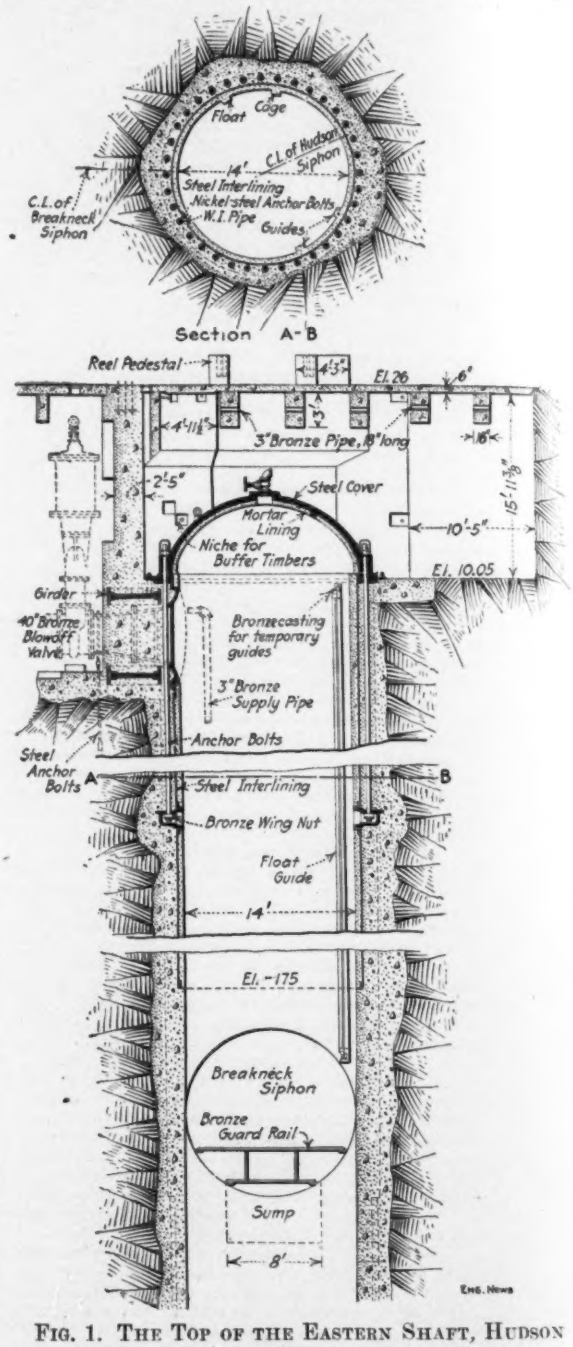

FIG. 1. THE TOP OF THE EASTERN SHAFT, HUDSON RIVER SIPHON, CATSKILL WATER SUPPLY

ter grip in the concrete. These sleeves, which are 5 in. in interior diameter, are to be filled with vaseline or some other mineral oil after the bolts are placed, so that the bolts will have a free movement between the anchor ring and the dome and be protected from corrosion. The bolts in addition are capped with bronze caps, as shown in Fig. 2, to protect their extremities from corrosion; and the

bolt opening through the base of the dome is lined with a driven brass lining so that there will be no rusting along that surface. The dome itself has been lined with about 3 in. of cement mortar before placing. Small screw-eyes were tapped into the inside of the dome and through them were woven wires, which served as reinforcement for the plastered lining.

It will be noted from a careful examination of Fig. 2 that great precautions have been taken to prevent any leakage of the water from the shafts or of any percolation of water to the metal parts. These precautions involve the use of calked joints in the steel interlining and the anchor ring, a special calked joint in the connection joint of the bolt sleeve, lead-wool calking in the junction of the bolt sleeves and the curb ring, and a specially designed rubber gasket in the joint between the curb ring and the dome itself.

Manufacture and Testing of Dome and Fittings

The manufacture and testing of the dome and its fittings involved many difficult engineering problems. The following notes on this work are by Emil C. Jensen, of the Midvale Steel Co., of Philadelphia, Penn., which company manufactured the dome and its fittings.

Casting the Dome—It was decided that no pattern would be used for this dome, but that the shape would be swept out. To this end a large flask about 20 ft. square was built up of solid steel frames, or plates, in such a way that the structure would be rigid while pouring the casting, and allow the loosening of the bolts holding the frames together so that the casting during cooling could freely contract and shrink without danger of cracking. That the contraction of a casting of this size is considerable, will be seen when it is remembered that steel shrinks in cooling about $\frac{3}{16}$ in. per ft., or, in this case, about 3 in. in diameter, and about $1\frac{1}{8}$ in. in height.

On the floor of the steel foundry large I-beams were closely spaced and covered by steel plates. (See Fig. 3.) In the center was located a bearing for the bottom end of the spindle of the sweep. This spindle was supported on top by a steel channel across the flask. The dome was to be cast with the concave side up on account of the heavy flange. The cope was made first, in the following way: a wooden sweep was cut to the inside contour of the dome and strongly mounted on the steel spindle supported as already noted. The flask was then filled with wooden ring on top of the drag, working in a corresponding groove in the arm. The surface was then smoothed over and painted with a thin portland-cement wash and covered with newspapers, as the shape in which it now appeared was to serve as a mold for the cope, and the papers

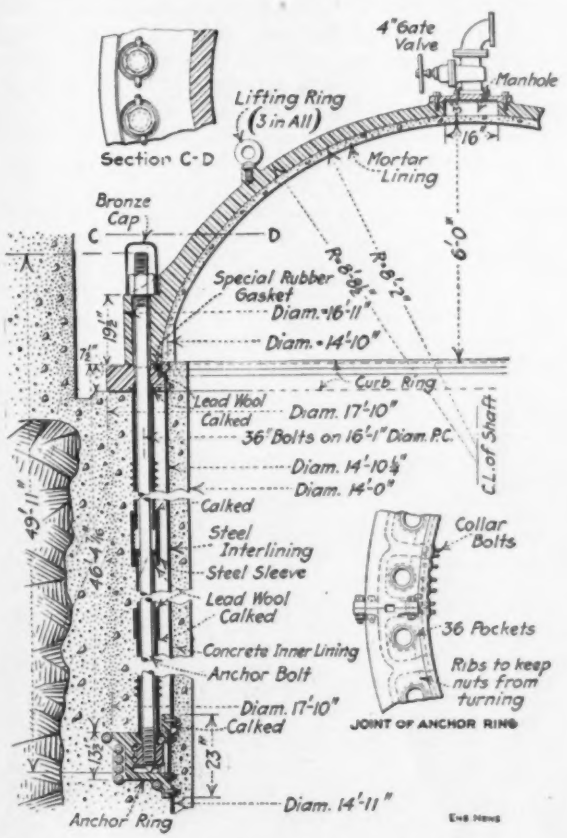

Fig. 2. Details of Cast-Steel Dome at Top of Shaft

were expected to prevent any adhesion between the surfaces. The cement also formed a very hard surface after being allowed to set in the air for several days.

The sweep was removed, but the spindle was left in place, supported as before, and facing sand to a thickness of about 5 to 6 in., was then carefully rammed all over

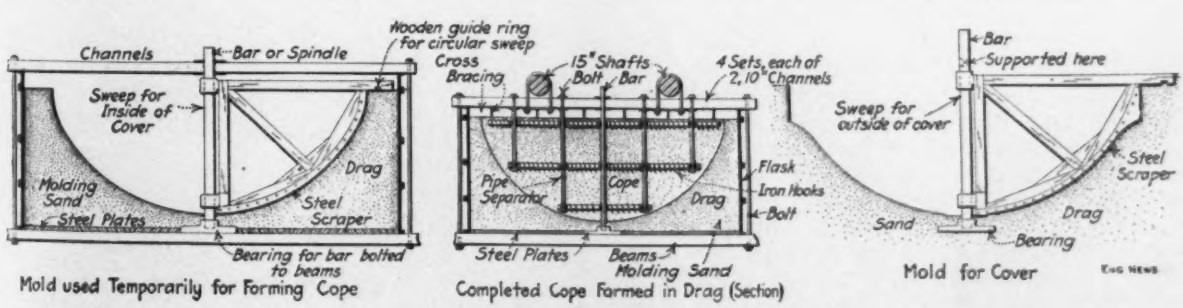

Fig. 3. Steps in the Casting of the Dome

old molding sand to somewhat near the shape of the sweep and then this was lined with new molding sand, well rammed and then swept to the exact size by rotating the sweep. The arm of the sweep was guided by a the bottom and well up on the side, after which a cast-iron crab was mounted on the spindle and supported on a piece of pipe, slipped over the spindle. The rim was wound with straw rope, which would burn out when the

heat from the casting struck it, and allow the sand to yield against the pressure of the contracting casting; numerous hooks were suspended from all available places to support the sand. The center part was filled with old sand and cinders to form a porous cushion. On the crab was mounted another pipe separator around the spindle and several 1½-in. bolts were led through the rim and leading up to the next crab above (not yet in place). Then facing sand and a cinder center core was built up, as before, until the position of the second crab had been reached, when it was put in place and securely bolted down. And so on, up to a third crab held fast to the second crab by a dozen or more 1½-in. bolts, all with pipe separators on. The second and third crabs were like the first one, only larger in diameter, and all had the rims wound with straw. The "teeth" on these crabs came within about 6 in. of the surface of the cope.

About 24 pieces of old gas pipe were built in as the work progressed to carry the gases away. When, finally, the top of the flask had been reached, the top of the drag was carefully smoothed up and the cement wash, parting sand and newspapers spread on the top surface, when

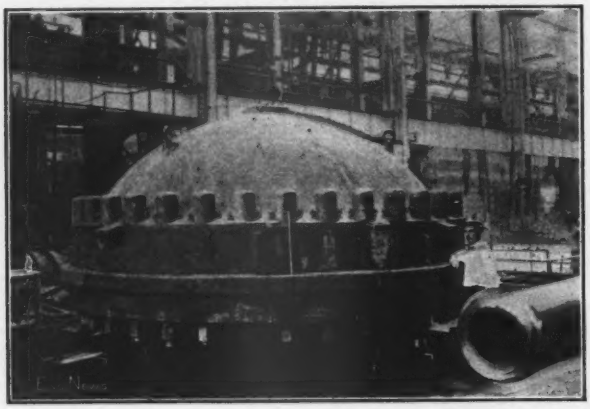

FIG. 4. VIEW OF THE DOME UNDER TEST

the work of the building up the cope proceeded. The bolts from the crabs were carried up between two channels, of which there were four sets, spanning the flask. All nuts were screwed tight, and the whole mass helped by the crosswork of steel bracings in the flask and the innumerable hooks suspended from them, was held solidly together. On top of this were laid two 15-in. steel shafts that happened to be on hand, each about 25 ft. long and securely bolted to the framework by U-bolts and clamps, these serving as attachment for the crane slings. The whole mass was then carefully lifted up.

That the greatest care had been exerted in molding was shown when the mold was parted, as the parting was almost perfect, not over three hours' work being necessary to repair the spalling of the facing. Neither was there any measurable sag in the core, a condition of the utmost importance. Any sag would have encroached on the thickness of the casting. The cope was left resting on steel blocking that had previously been prepared and carefully leveled up alongside the mold. After smoothing the surface, the cope was studded with nails to prevent washing away of its surface in casting. It may here be of interest to note that about 11 carloads of sand were used in the mold and about 20 kegs of nails for studding the cope and as many more for studding the drag, and that the cope had about 20,000 lb. of metal in it and weighed complete about 240,000 lb.

The mold that had served for the cope was next dug out to a further depth, agreeing with the thickness of the casting and a strip was bolted on the edge of the sweep, so that it now represented the outside contour of the dome, resting at bottom and top on the same surfaces as before and guided at the arm by the guide ring, without which it had been found that there was considerable sag in the sweep. The mold was swept out as before, smoothed, holes for runners were cut and surface nailed up, as with the cope. Four lugs were located at the flange and given such a slope on the underside that in shrinking vertically as well as diametrically there would be no danger of the casting being left hanging on these lugs so that it would probably crack. The runners were located at the near edge of the flange and near the bottom of the casting.

The cope had in the meantime been completed and had been surrounded with sheet iron, and a slow coal fire built in crates so as to give an even, uniform heat. Similarly, a fire was built in an iron basket in the drag, and all covered over with sheet iron. After thoroughly drying for several days, the parts of the mold were put together, after first locating several clay balls at different points of the surface. The cope was then lifted up again and the thickness of the clay balls now measured. This gave the thickness of the steel casting at these points and showed that no deformation or sag had taken place in the mold. The cope and drag were matched by scratch marks and dowels on the frame locating the proper position and then everything made secure by clamps and straps and bolts from the bottom I-beam up to the top channels.

It took four months to make this mold. The casting was poured through the runners from two ladles. The capacity of one ladle was 124,000 lb., which filled the mold, but did not entirely fill the risers, so another ladle was brought on and poured 14,000 lb. more into the risers until filled. Everything was then loosened up to allow free contraction of the casting.

It may be noted that the finished casting weighed 92,500 lb., the difference between this weight and the cast weight being mainly the twelve 15x48-in. risers that rose vertically from the top to the rim, spaced about equally around. No holes were cored in the casting, except the central hole 16 in. in diameter in the crown of the dome. After having been left in the mold for 12 days, the casting still retained a very considerable heat, but was then cleaned on the inside, the outside clearing itself when it was lifted out to be put in a special annealing furnace that had been built alongside.

After a thorough annealing, the casting was taken out and tested from the runners, from coupons on the rim, and later from core drilling in four of the anchor-bolt holes. The results obtained average as follows:

	Tensile strength	Elastic limit	Elongation	Contraction
From runners	65,500	34,000	30%	56%
From coupons	68,000	36,250	30.6%	57.2%
From core drilling in bolt holes	65,500	37,500	26.8%	38.8%

MACHINING THE DOME—The machining of the dome was a lengthy and difficult process, owing to its size and shape. In all it took 14 weeks to remove the casting risers, drill the bolt holes (which alone took four weeks) and finish the bearing surface and spot the nut bearings.

Testing the Dome—The contract called for the casting to sustain a hydraulic pressure of 250 lb. per sq.in. for 24 hr. In order to do this, it was necessary to make a bottom for the dome. This test plate was 12 in. thick, 17 ft. in diameter and had thirty-six 6-in. cored holes around the rim for the test bolts holding the dome, curb and test plate together. On the top face were two circular ledges, about 1½ in. wide by ¾ in. high and the top face of these ledges was the only part to be machined on this casting, except spot facing around the bolt holes on the bottom face. This casting weighed 114,000 lb. without risers and 158,000 lb. as cast with eight 18-in. risers.

To secure tight joints during the hydraulic testing of the casting, a soft-rubber gasket semicircular in section with $\frac{3}{16}$-in. radius was placed in the tongue-and-groove between the curb and cover. Although this rubber gasket was compressed only $\frac{3}{16}$ in. when the castings were metal to metal, this gasket sustained the total weight of the cover and bolts about 102,000 lb. without even compressing this $\frac{3}{16}$ in., and it was only after some tightening up on the bolts that the joint was entirely closed. The gasket gave good service. The joint between the curb and test plate was made by a ⅜-in. diameter soft-copper wire. Although this wire was pressed between machined faces on the castings and compressed by tightening on the bolts to ¼-in. thickness, it still was unable to hold a pressure of more than about 170 lb. per sq.in., without a very excessive leaking, most likely due to the dishing of the bottom test plate. The addition of a soft-rubber gasket bent U-shape on the inside of the copper wire was no more successful, so it was changed for a soft-rubber gasket, also bent U-shape and held open by several hundred small wooden wedges, so that the water would not enter back of the gasket and close it up. In this way the test pressure of 250 lb. per sq.in. was successfully held for 24 hr., although there was some leakage in spots, where by mistake some of the wedges had been put between the gasket and the casting, instead of into the fold of the leather. Fig. 4 shows the castings under test, and also shows the bronze caps that protect the tops of the anchor bolts from moisture.

The deflection of the castings were as follows: the test plate bulged down in the center 0.12 in. and bent up at the edges 0.125 in., a total of ¼ in. The dome at the top raised up 0.15 in., from which should be subtracted the rise at the edge, 0.125 in., leaving about 0.03 in. net vertical heightening of the dome. The radial deflection of the dome was not measured in a satisfactory way, as only three points were taken, but there were indications of a slight radial contraction, as might be expected.

The manhole on top of the cover was made tight by a thin-lead washer and showed no leakage whatever.

Anchor Bolts—The 36 nickel-chrome steel-anchor bolts, 4½-in. diameter and 50 ft. long and a nut of the same material on each end, with a Whitworth thread, deserve a few words. Each bolt was smooth forged in one piece, under a hydraulic press, and had proper enlargements on each end for finishing where threaded and also a suitable excess in length, as each bolt had standard 2x½-in. test bars from both ends.

After forging, the bolts were suspended vertically in a vertical heating furnace, capable of taking lengths up to 70 ft. After having been given a thorough and uniform heating, the bolts as suspended were lifted out of the furnace and lowered into a vertical-subterranean double tank, with the tempering fluid in the inner tank and the cooling water in the annular space between the tanks. After some few moments submerging in these tanks, the bolts were again lifted up and suspended in the same furnace for the purpose of drawing the temper. By keeping the bolts continually vertical, especially while heated, they were kept fairly straight, but even then it was necessary to further straighten each bolt in a hydraulic straightening machine, as the sleeves in which the bolts were to be used allowed only a variation of about ¼ in. out of line.

The specifications called for:

Tensile strength	100,000 lb. per sq.in.
Elastic limit	80,000 lb. per sq.in.
Elongation	20%
Contraction	45%

Owing to the great length and slenderness of these bolts, it was difficult to get identical results from both ends of a bolt, as the upper end would have cooled somewhat before it had been lowered into the tempering fluid and also the lower end would naturally remain the longest in the bath, being the first to enter and the last to leave it, but these difficulties were finally overcome and good results were obtained. Tests of the bolts are given in the following table:

	Tensile strength lb. per sq.in.	Elastic limit lb. per sq.in.	Elongation	Contraction
(1)	114,500	82,000	22.5%	62.6%
(2)	116,500	83,000	22.5%	62.3%
(3)	125,000	102,000	21.2%	62.6%
(4)	130,000	113,000	21.1%	61.1%
(5)	118,500	91,200	21.3%	62.5%
(6)	119,300	89,200	21.1%	61.7%
(7)	120,500	93,300	20.5%	61.6%
(8)	121,000	91,700	21.1%	60.7%
(9)	121,500	91,700	20.6%	62.6%
(10)	107,000	86,000	1 ft. in 20 ft.	60%
(11)	114,000	87,000	4 in. in 2 ft.	60%

A typical test from both ends of a bolt is given as (1) and (2). None were accepted below specifications and the highest results are shown as (3) and (4). The average of all bolts for both ends is given as (5) and (6).

To test the actual strength of the anchor bolts, it was decided that one of the bolts should be broken, full size. It was, however, found that no testing machine in this country was both long enough and strong enough to do so. Only two machines had the requisite strength, namely, the testing machine at Phœnix Iron Works, Phœnixville, Penn., which has a capacity of 2,800,000 lb. and can break eye-bars up to 50 ft. long, but owing to special rigging needed, can only break bolts as this one, up to about 40 ft. long; the other machine is the one at the Bureau of Standards, Washington, D. C., having a capacity of 1,150,000 lb. for tension and 2,300,000 lb. for compression, and can only break up to about 34-ft. lengths. The bolt was, therefore, cut into two pieces, one piece was upset near the ends to 5½-in. diameter for threading. The pieces were annealed and then clamped together, so as to hang in continuation of each other, as if they had one bolt of the original length of 50 ft. In this position they were subjected to exactly the same treatment and under exactly the same conditions. Nine test bars were taken from the two pieces, three from each of the extreme ends and three from the part that had been the middle of the original bolt. These tests averaged as shown in (7) and (8) for the two extreme ends and as shown in (9) for the middle.

The upset bolt was threaded at the upsets to 5-in. diameter for nuts, but was otherwise left rough. This

bolt, about 20 ft. between nuts, was broken at the Phœnixville Iron Works. It took 1,716,000 lb. to break it and gave the results opposite (10).

The other piece was threaded at the ends to 4½-in. diameter thread and at the middle for a distance of 2 ft. was turned down to exactly 3½-in. diameter; this bolt, about 17 ft. between nuts, was broken in Washington at the Bureau of Standards, it broke under a load of 1,096,000 lb. and gave the results opposite (11) in the table.

Rings—The rings were not particularly difficult to cast or machine. The curb was cast in its entirety, using a part of the flask prepared for the dome. The anchor ring was cast in four quadrant sections, all from one quarter-section pattern, and was bolted together in a circle when placed. After machining, each of the 36 pockets, shown in Fig. 2, was tested to a hydraulic pressure of 200 lb. per sq.in.

Transportation

On account of the size and shape of the dome and ring, considerable difficulty was anticipated in transporting them from the mill, near Philadelphia, to the shaft site. It was at first intended to team them to the Delaware River, and ship them from there by barge, via the river and the Raritan Canal. It was found, however, that they could be loaded on special flat cars, each having a large aperture, or well, through (by removing) its bottom, thus swinging the castings about 4 in. above the rail. Proceeding slowly, the special train carrying them, safely reached the Greenville, N. J., yards of the Pennsylvania R.R., whence they will soon be transported by barge to the site.

Erection of Dome

During the construction of the steel cover, the shaft lining of concrete and steel was brought up to the elevation of the anchor ring. This ring was then placed and the final cleaning and repairs of the concrete shaft lining completed. After the completion of the excavation for the chamber at the top of the shaft, the lower nuts for the anchor bolts are to be put into the pockets in the anchor ring and the pipe sleeves of the anchor bolts erected with their lower ends entered in the sockets in the top of the anchor ring. The concrete and steel lining will then be completed and the curb set. When the concrete is of suitable age, the cover and bolts will be placed and the nuts screwed on to the upper ends of the bolts.

In placing the dome it is highly desirable that the anchor bolts be initially stressed to their ultimate elongation under the total load, so that when the water pressure is applied there will not be any appreciable movement of the cover under that pressure, and also to provide for temperature changes. To this end a special jacking device has been designed for the Hudson shaft dome. After the shaft has been completed to the point noted in the preceding paragraph, the dome is to be lowered to its seat on the curb ring and the anchor-bolt nuts screwed down to an easy bearing. Then the special lug nut, shown in Fig. 5, is to be screwed on the bolt above the permanent nut and to this lug nut will be attached the stressing-link device shown also in Fig. 5. Between the transverse beam of the device and the special base standard, one of which is made to fit over each of the two nuts adjacent to the one being stressed, there will be placed hydraulic jacks, which will be used to force up the special nut until the bolt is stressed to the same amount as it will be in its final condition under full load. Four of these devices are provided, so that the stressing of the bolts may proceed by small increments uniformly around the ring, bolts diametrically opposite being selected for the successive stressings. When the bolt has been sufficiently stretched for each increment by which the total load will be applied, the main nut will be screwed down to a firm bearing and the jack released.

Future Operations

The shaft chamber is so designed that the pumping float will be housed above the dome in a special recess. When the shaft and siphon are to be drained, the procedure will be as follows: First the flow of water in the aqueduct will be shut off at some point nearer the source

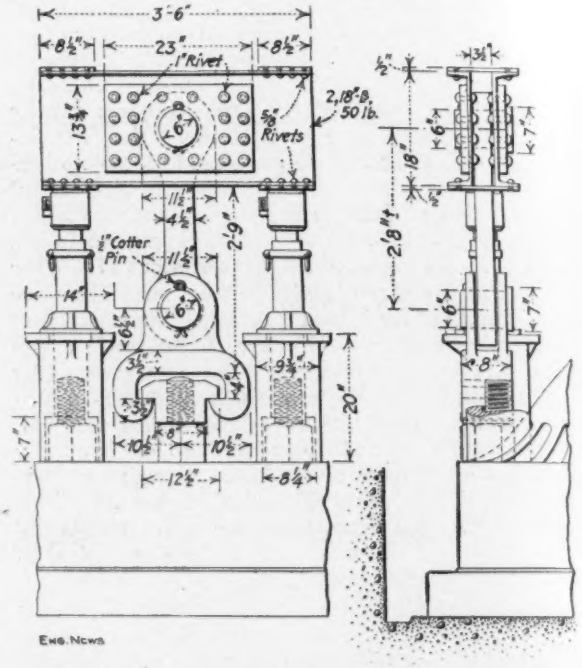

Fig. 5. Device for Producing Limited Stress in Bolts

of supply. Then the portions of the Hudson siphon and the adjacent parts of the aqueduct above river level will be drained through blowoff valves near the top of the east shaft, just under the dome, the water being discharged through a stilling chamber shown in Fig. 1, into the river and the dome lifted by devices provided for that purpose, until it is at sufficient height to place under it a special set of wheels, bolted to holes provided. It will then run on tracks into a chamber alongside of its permanent location. The pumping float will then be run in from its permanent chamber and placed in position on its guides in the shaft, there to continue down the shaft as pumping progresses. The water pumped will be discharged into the adjacent Hudson River.

Personnel

The design and construction of the shaft is in charge of the Board of Water Supply, J. Waldo Smith, Chief Engineer; Merritt H. Smith, Deputy Chief Engineer.

The design, inspection and supervision of manufacture, was under the Headquarters Department, Alfred D. Flinn, Deputy Engineer; field construction is under supervision of the Northern Aqueduct Department, Ralph N. Wheeler, Deputy Engineer. The T. A. Gillespie Co. are general contractors, for whom the Midvale Steel Co. made the steel dome, curb, anchor ring and anchor bolts with all accessories.

A New Strain-Gage for Live-Load Stresses

A compact and handy form of strain-cage designed by J. E. Howard, of the Bureau of Standards, Washington, D. C., and constructed in the Bureau's shops, was tried out a short time ago on the towers and stiffening trusses of the Williamsburgh Bridge over the East River, New York City. The robust character of the instrument in connection with its great sensitiveness of reading is one of its prime features. Its field of use seems to be, mainly, measuring live-load strains which occur and pass away within a short time, as a few minutes.

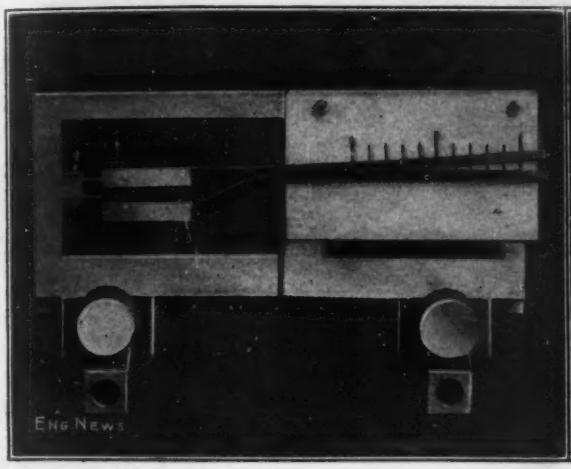

FIG. 1. FRONT VIEW

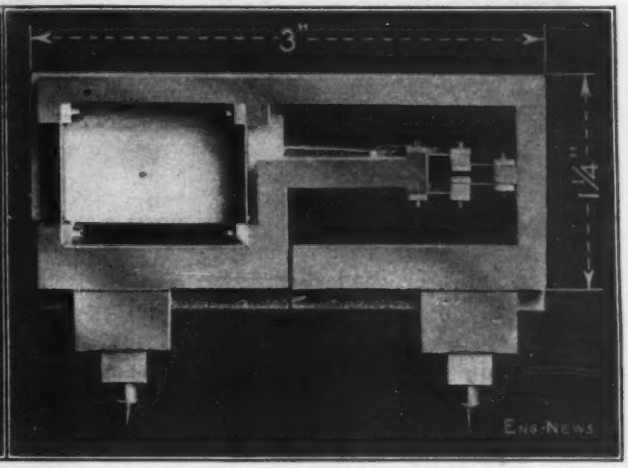

FIG. 2. BACK VIEW

LIVE-LOAD STRAIN-GAGE USING SCISSORS PRINCIPLE

Two photographic views herewith show the front and the back of the instrument. As marked in the photograph, the instrument is about 3 in. long and 1¼ in. wide over the body. Its lower edge carries a dovetail rib on which slide two clamps for holding extension bars. By means of these bars the gage may be made to take any desired distance between gage-points (e.g., 2 in., 10 in., 20 in.), depending upon the range of stress to be expected in the member in question.

The instrument is connected to the member to be tested by setting the conical gage-points in center-punch marks in the member, and holding them in place by means of weights, clamps, or whatever other means may be convenient in the particular case.

As shown by the back view of the instrument, Fig. 2, its frame consists of a main yoke and an auxiliary frame arm connected with the main yoke by two thin strips of steel extending transversely across the width of the instrument. These strips are links permitting the auxiliary member to move longitudinally with respect to the main yoke, and the measurement of this movement constitutes the object of the further details of the instrument. The rear of the auxiliary member is connected by two thin metal strips or hinge plates, whose direction is longitudinal to the instrument, with two steel blocks which constitute the short arms of a pair of bellcrank measuring levers, and these in turn connect by two similar steel strips to the end piece of the main frame yoke. The two pairs of strips are not in alignment, but are offset with respect to each other, as may be seen clearly in Fig. 2, and thus exert a turning effect on the two measuring levers, tending to make them turn in the plane of the instrument. In the front view, Fig. 1, the long ends of the measuring levers are seen. They are crossed over each other like two scissors blades, and the point of intersection of the inner edges of these blades can be located on a celluloid scale back of the blades. The longitudinal shift of this point of intersection is the reading, i.e., the desired measurement of extension.

In the instrument as built the proportions are such that a longitudinal shift of the scissors vertex by one graduation represents a length change of one ten-thousandth in. (0.0001 in.). The total length of graduation is 1 in., this inch corresponding to 0.001 in. elongation or contraction. The instrument can be read easily to tenths of a division, and its sensitiveness is therefore 0.00001 in. What this means in stress measurement is computed as follows: Suppose the instrument is attached to a girder flange, using gage-points 10 in. apart, suitable extension bars being used. As a wagon passes over the bridge the intersection of the levers shifts from graduation 1 to 9, i.e., 8 divisions (which movement is in the direction of tension) and back again. Then the elongation on 10 in. under the passing load was 0.0008 in., or 0.00008 in. per in., which, for an elastic coefficient of 30,000,000 lb. per sq.in., denotes a unit-stress of 2400 lb. per sq.in.

In this case, therefore, the instrument indicates 300 lb. per sq.in. for each division, and its full scale of 10 divisions embraces a stress-range of 3000 lb. In testing a more severely stressed member, larger range would be secured by using a shorter measuring length; e.g., for a 2-in. gage length the range would be 15,000 lb. per sq.in.

Electric-Carrier Railways for Rapid Transfer of Mail and Express*

(*Concluded from p. 637, Oct. 2, 1913*)

(II) System of the American Pneumatic Service Co. and the Cambridge Demonstration Plant

An electric-carrier railway for mail and package-express transfer, has been developed by the American Pneumatic Service Co., of Boston, Mass., the concern which has installed large pneumatic mail tubes in Boston, New York, Chicago and St. Louis, and which controls the companies operating them under U. S. Mail contracts.

No line of such a carrier railway is in commercial service as yet, but this company has a large-scale demonstration and experimental plant at Cambridge, Mass., where the complete system is shown working. There is seen about one-third of a mile of track, part in 30-in. cast-iron pipe (234 ft.) and part in a skeleton-tube construction shown in Figs. 1 and 2. The track follows the sides of a rectangular lot, the corners being made with 90° curves of 50-ft. radius. One corner is also at the summit of a 5% grade, these curves and grades being considered by the designers, from their experience, as the maximum that would be necessary for such a carrier railway. At one point, a short section of concrete tunnel of elliptical cross-section, 7 ft. wide and 6 ft. high, has been built to show how two skeleton tubes would be run

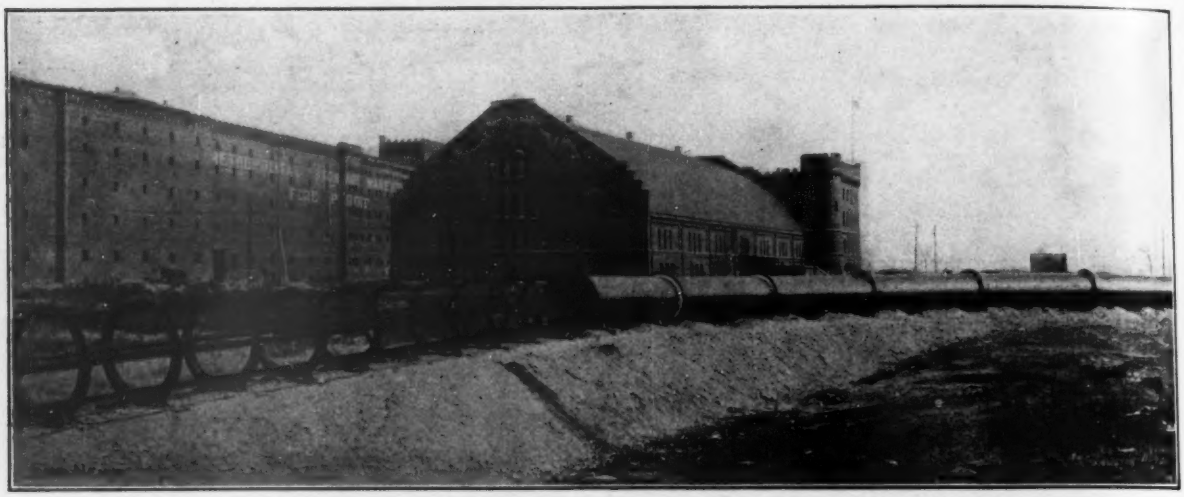

Fig. 1. Electric-Carrier Railway of the American Pneumatic Service Co., in 30-In. Cast-Iron Pipe and Skeleton Tube

The system comprises essentially a tube having one running rail, two side guide rails, and an overhead trolley conductor insulated from the tube structure. Through this runs a steel car of generally circular cross-section with a length some three times the diameter. The car is built up of strong steel end castings joined by longitudinal cradle connections supporting a steel-plate carrier body. A single central wheel at each end-casting supports the car; one of these, the forward wheel, is geared to a direct-current constant-speed (shunt-wound) motor, as shown in the accompanying figures. The operation of the car between terminals is entirely automatic.

*In the preceding section of this article appeared some general notes on railway-mail and express transfer service by tube railways where large pneumatic tubes would be inadequate. There was also a description of the unique alternating-current propulsion system of the Electric Carrier Co., of New York, and an experimental line at Paterson, N. J.

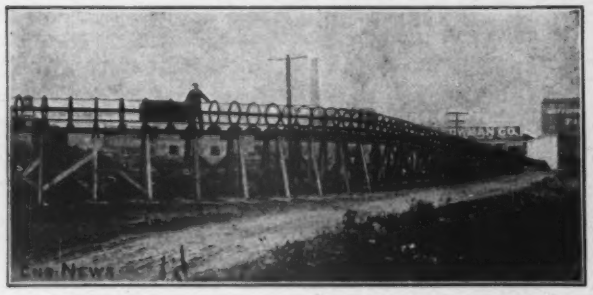

Fig. 2. Carrier-Railway Track on 5% Grade and 90% Curve of 50-Ft. Radius

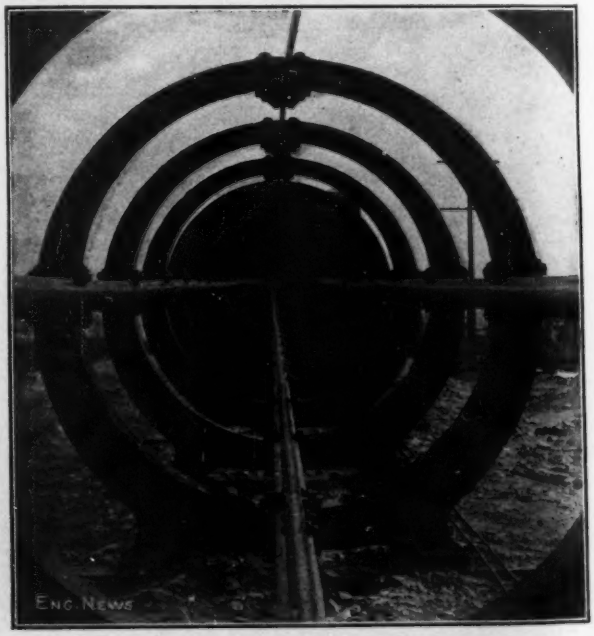

Fig. 3. View Along Carrier Railway Track in Skeleton-Tube Construction

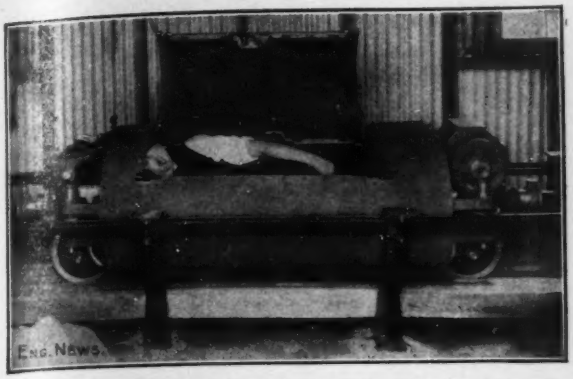

FIG. 4. ELECTRIC MAIL-CARRIER CAR OF AMERICAN PNEUMATIC SERVICE CO., ON LOADING TRACKS
(For 30-in. tube.)

through a single tunnel when that construction would be preferable to two pipes. The track passes through a temporary steel building fitted up as would be a dispatching and receiving station.

In the detail design of the cars, every effort seems to have been made to secure simplicity. There are no motor-starting rheostats, etc., and the motor is connected directly between a short T-bar trolley arm (running against the overhead conductor) shown at *A* in Fig. 5, and the grounded car frame. There is an auxiliary contact arm *B* on (insulated from) the rear-end casting, electrically connected in parallel with the regular trolley arm *A* and moved out by a handle *C* to make contact with a side conductor rail *E*, at the tube stations. This handle has a stop *D* and a spring which returns the contact head to dead position when the attendant lets go. As seen in Figs. 4 to 6, at stations the overhead conductor is discontinued and its place taken by the side conductor *E*, Fig. 5. This rail is connected to the supply circuit through resistance to give easy starting and slow movement in the station. In dispatching a loaded car, the attendant pulls out the auxiliary-trolley handle and walks along to the tube entrance; when the car has sufficient velocity to make the entrance, the attendant lets go, the auxiliary trolley flies back out of service, the main trolley bar picks up current at full voltage from the overhead conductor and the car quickly runs up to normal speed which it maintanis, approximately, until entering the distant terminal section. Back of the trolley baseboard is a field-reversing switch to reverse the motion of the car, but this is provided for emergencies and not regular service. A turntable is used to transfer cars to and from sidings, and is used for reversing a car when it is desired to dispatch it in the same direction from which it came. The table is easily swung by hand.

Braking of the car on entering the station is secured by letting it slide along on wood track skids, which take the weight off the wheels. Between the skids and the cars are two maple-faced shoes, which, however, can be lifted by the station attendant, so that the car can be run along out of the way of the next one, the shoes drop automatically as the attendant lets go the lift handle, so that a car cannot be dispatched unprepared to stop properly at the other end.

The cars used at the Cambridge plant are 7 ft. 3½ in. long between buffers. The carrier body is 4 ft. long and 25 in. inside diameter. The cover is a single curved

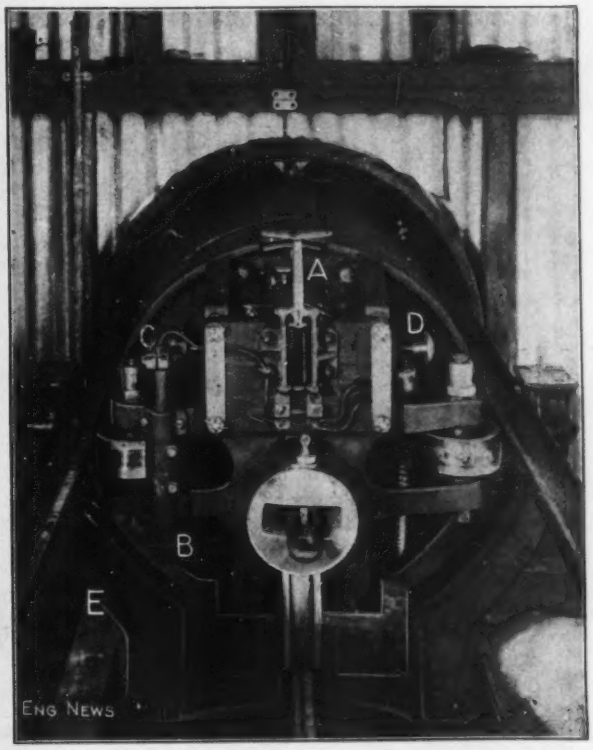

FIG. 5. REAR END OF ELECTRIC MAIL-CARRIER CAR

plate hinged at both longitudinal edges, the hinge-pins serving as lock bolts. By throwing a handle at either side, the hinge-pins are shot back on that side and the cover opens toward the other side as shown in Fig. 6.

Cars can be equipped with trips or contact devices to give indication of passing different points in the tube line, or for operating turnout switches for station sidings,

FIG. 6. ELECTRIC MAIL-CARRIER CAR ON LOADING TRACKS, SHOWING FRONT END AND TRACK BRAKE SKIDS

etc., though no such equipment is shown at the Cambridge plant. When a turnout is necessary, the bottom rail would run to a stub switch while the converging inner guide rails would come to a combined frog and split-switch with a long point and 30 in. of point travel.

The system outlined above has been developed by B. C. Batcheller, chief engineer of the American Pneumatic Service Co.

The Broadway Bridge over Willamette River, Portland, Ore., with Rall Bascule Span

By W. P. Hardesty*

Portland is divided by the Willamette River into two portions, "East side" and "West side." The older or West side is the site of the original city. East Portland was a separate city, much smaller in population, but about twenty years ago it was consolidated with the other.

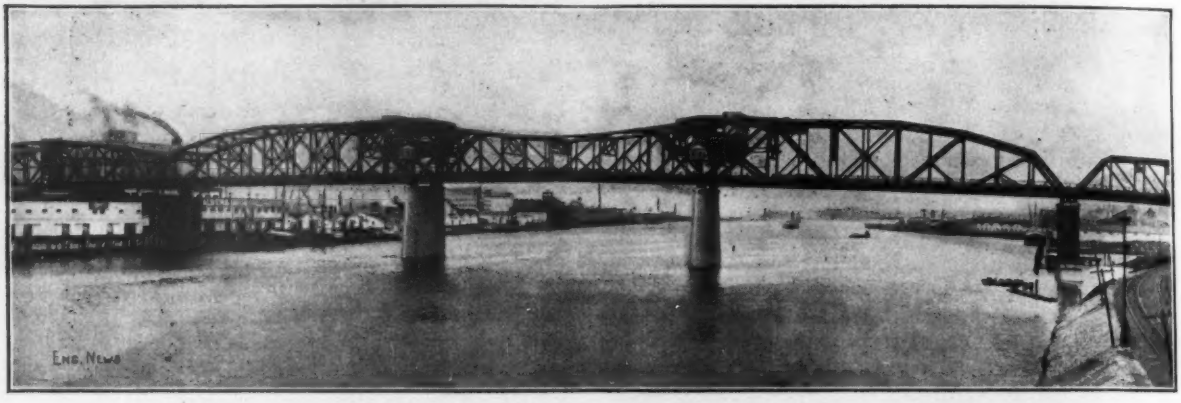

Fig. 1. Broadway Bridge at Portland, Ore., Looking Northwest down the Willamette
(Stone-faced concrete piers sunk by pneumatic process to firm gravel. Bascule span 278 ft. c. to c.)

With the rapid growth of Portland during the last six or seven years, the East side has expanded until it now contains 75% of the total land area and two-thirds of the population, although the West side remains the business center.

The city has outgrown in succession the original ferry system, the earlier light bridges and the rebuilding of the same, until the past four years there has been a pressing need for new bridges lower down the river to accommodate the heavy traffic between the West side and the very rapidly-growing "Peninsula" district of the East side.

The Broadway bridge is constructed across the Willamette at a site formed by the direct southwesterly extension across the river of Broadway from the East side, and is ¼ mile downstream of the lowest previous bridge. The width of the river between harbor lines is about 800 ft. West of the river the bridge continues on over dry land southwesterly for about 700 ft., then takes a bend to the south, and descends by a long approach on Broadway (West side) to the street level at Hoyt St. The total length over all is 2987.5 ft., reaching from Hoyt St. to the intersection of Broadway and Larrabee.

The bridge consists of two Pratt-truss and four Baltimore-truss spans 125 to 297 ft. long, and a two-leaf bascule span 278 ft. long. There are also approach sections of plate-girder spans, and retaining-wall roadbed construction. The gradients on the bridge are 3.8% maximum, except for an auxiliary entrance whose approach rises 4.5%. The ascent to the center of the bridge is for the purpose of providing clearance for river craft. The clearance in the center is 65 ft. at high water and 93 ft. at the lowest stages. This will permit passage of most of the river steamboats and smaller ocean-going vessels at the highest stages, and there seldom will be need of opening the draw except for passage of sailing vessels. The clearance is only 9 ft. less at the harbor lines than at the center, permitting free movement of the smaller craft without reference to the bridge spans.

Substructure

The main part of the river bed at the site is nearly level, about 39 ft. below the lowest water. The bed is mostly black sand underlaid with black gravel; cemented gravel is found at the east side. At the west end, where the ground is naturally low-lying and has been largely filled in, the thickness of sand is much greater and the sand is finer. So far down the river in Portland solid rock would not be expected short of several hundred feet depth. Borings at the bridge site to a depth of 130 ft. showed nothing harder than the gravel.

The river piers, Nos. 4, 5, 6 and 7, were sunk by the pneumatic process. Timber caissons were used. The cutting edges went down to the following depths below low water (zero of gage): Pier 4, 85.25 ft.; Pier 5, 82.92 ft.; Pier 6, 75.62 ft.; Pier 7, 32.64 ft.

At Pier 4, near the west shore, the excavation was to 73 ft. below the river bed and the immersion was 101 ft., giving a pressure of 44 lb. This depth is only 10 ft. less than the record depth for pneumatic work, reached for the new Municipal Building at New York. Shifts of two hours each were worked by the caisson men.

All of the piers extended a foot or more into the gravel. For pier 7 (at the east shore) hard cemented gravel was entered and some blasting in it was done.

The caissons for Piers 4 and 7 were 20x68 ft. From the top of each one (near low water) two pedestals rise to an elevation, about 31 ft. above low water. These

*Civil Engineer, 60 East 31st St. N., Portland, Ore.

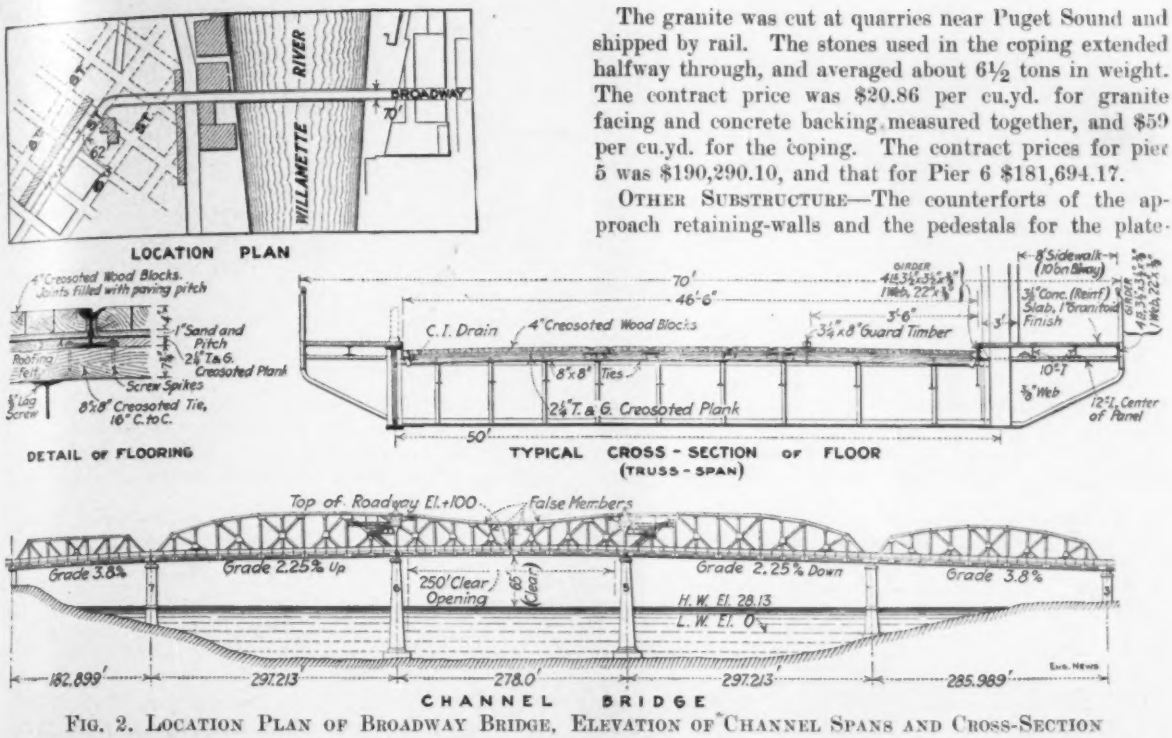

FIG. 2. LOCATION PLAN OF BROADWAY BRIDGE, ELEVATION OF CHANNEL SPANS AND CROSS-SECTION

(False members at the junction of the bascule leaves were added at the mayor's request, after the preliminary design, to give a greater effect of security in the appearance and to make the outline more symmetrical.)

pedestals are 50 ft. apart c. to c., and 14 ft. square under the coping, and batter at the rate of ½ in. per ft. They are reinforced with 1-in. Johnson bars that project 6 ft. into the concrete of the caissons; some of the bars also project into the steel cylinders above. Each pedestal is surmounted by a coping, which contains also horizontal reinforcing. On each pedestal is a steel cylinder 12 ft. in diameter filled with concrete, reaching to the proper height for the bridge seats. The two cylinders are very strongly conected together by riveted steel bracing. Each is capped with a 3-ft. coping, ending at elevation 80 ft. above low water.

BASCULE PIERS—The piers that carry the bascule span, Nos. 5 and 6, are on caissons 33x90 ft., by 50 ft. high. The pier bodies are of concrete, with granite facing. Their width under the belt-course is 10 ft., and the length between shoulder points 56 ft. (72 ft. between nose points of the conical ends). The top of coping is 87 ft. above low water, making the total height above the river bed about 125 ft., and the total height above the footing about 170 ft. for Pier 5 and 163 ft. for Pier 6.

The granite facing of these two piers is of alternate stretchers and headers, the former reaching into the pier about 3 feet and the latter about 5 feet. To preserve the uniformity of appearance in the courses, the thickness of the courses varies with the width of the pier at different elevations. The first 24 courses are 2½ ft. thick, the next 9 are 2¼ ft., and other reductions are made with the height so that the last regular course is 22 in. Above this the belt course projects 6 in. all around, and the coping course projects 9 in. farther, making the width on top 12½ ft. The last three courses and the belt course and coping are of granite throughout, in order to better distribute the weight of the superstructure over the entire surface of the pier.

The granite was cut at quarries near Puget Sound and shipped by rail. The stones used in the coping extended halfway through, and averaged about 6½ tons in weight. The contract price was $20.86 per cu.yd. for granite facing and concrete backing measured together, and $59 per cu.yd. for the coping. The contract prices for pier 5 was $190,290.10, and that for Pier 6 $181,694.17.

OTHER SUBSTRUCTURE—The counterforts of the approach retaining-walls and the pedestals for the plate-girder spans, as well as Pier No. 1, are founded on driven reinforced-concrete piles.

Piers 2 and 3 are founded on timber piles, and below the surface of the ground they are continuous across the bridge, but above the ground two pedestals surmounted by concrete-filled cylinders are used, similarly to those of Pier 4.

The following is the contract cost of the substructure of the bridge, including approaches:

FINAL ESTIMATE FOR BROADWAY BRIDGE SUBSTRUCTURE

Dry earth excavation, 4387 cu.yd.	$1.00
Timber foundation piling, 18,836 lin.ft.	0.40
Reinforced-concrete piling, 14,050 lin.ft.	1.80
Reinforced-concrete sidewalk, 11,451 sq.ft.	1.05
Concrete retaining-walls and abutments, 1 : 3 : 7, 159 cu.yd.	10.90
Pier concrete, 1 : 2½ : 5, 6508 cu.yd.	11.00
Pier concrete, 1 : 2 : 5, 00 cu.yd.	11.45
Pier concrete, 1 : 2 : 4, 500 cu.yd.	11.70
Foundation caissons, 17,110 cu.yd.	11.05
Caisson sinking, 23,493 cu.yd.	2.84
Granite coping and belting courses, including backing, 256 cu.yd.	59.00
Steel cylinder and bracing, 339,875 lb.	0.061
Johnson bars and reinforcing steel and anchor bolts, 226,275 lb.	0.0535
Cut granite facing masonry, 8747 cu.yd.	20.86
Wet earth excavation, 920 cu.yd.	3.00
Cemented gravel excavation, 212 cu.yd.	6.00
Contract cost as per above	$607,828

The total cost will include a proper proportion of the fee paid the engineer (R. Modjeski) for the entire bridge.

SUPERSTRUCTURE

The bridge was designed for the following live-loads:

FLOOR AND GIRDER SPANS—On each of the two street-car tracks a train of two interurban cars weighing 103,000 lb. each; on the roadway a 24-ton truck, and 100 lb. per sq.ft. on remaining surface; on the sidewalk 100 lb. per sq.ft. for spans of 100 ft. and less, and 110 — 0.1 s for spans over 100 ft., s being length of span in feet.

MAIN TRUSSES—On each car track a uniform load of 2000 lb. per lin. ft.; on each of the two roadways 1000 lb. per lin. ft.; wind pressure, 30 lb. per sq.ft. of exposed surface.

The superstructure of the main bridge is 70 ft. wide over all, 50 ft. c. to c. of trusses, and 46½ ft. between curbs.

The weight of steel in the different parts of the bridge is as follows:

Viaduct at W. end	750 tons
1st span	290 tons
2d span	885 tons
3d span	935 tons
4th span	1218 tons
5th span (Bascule)	1860 tons
6th span	1218 tons
7th span (at E. end)	475 tons
Hand-railing, drainage pipes and castings	140 tons
Stairways to street	36 tons
Machinery	105 tons
Total	7912 tons

The two counterweights weigh about 1150 tons each.

The steel and the workmanship on the bridge were in accordance with Modjeski's specifications for steel bridges.

FLOOR—The floor system, except on the bascule spans, consists of 8x8-in. ties, on which is 2¼-in. longitudinal plank carrying a pavement of 4x4x8-in. wood blocks laid on a ½-in. sand cushion on tarred paper. All timbers, including the blocks, were creosoted with 14 lb. per cu. ft. The sidewalks are of reinforced concrete, except on the bascule span, where creosoted wood boards were used. The flooring of the bascule span is Shuman flooring. A double track of 116-lb. rail is laid on the bridge.

BASCULE SPAN

The preliminary plans for the two-leaf bascule draw-span were prepared so that bids were invited on four different types, as follows: Strauss bascule, Scherzer rolling-lift bridge, Strauss modified designs* and Rall bascule.

The bids received for the entire superstructure, using the different types of bascule, showed that the Pennsylvania Steel Co. was low on all designs. Its bids were as shown in the table on p. 707.

BIDS NOT GIVEN

The totals showed a saving in favor of the Rall type (the same remark applies to the bids of the three other contractors). The Rall type was finally adopted, after a spirited contest by representatives of the other types.

The Rall patents are controlled by the Strobel Steel Construction Co., Chicago. The Rall span is, in a certain sense a rolling-lift span. Each leaf consists essentially of two trusses, each supported by a roller and with a short back arm or tail, so counterweighted that but small pressure is needed to make the leaf rotate about the shaft of the roller. The leaf has, at the same time, a longitudinal movement given by the travel of the roller on its track, so that the two movements combined lift the main arm of the leaf into a nearly vertical position and at the same time move it back from the channel, so as to secure a greater clear width of open channel. Other essential features are: operating struts for moving the leaf on and around the rollers, by overcoming inertia and friction; swing struts or control struts, for regulating the travel of the rollers; and anchor arm ("struts") for carrying the strain of live-load back to the adjacent anchor span when the draw is closed.

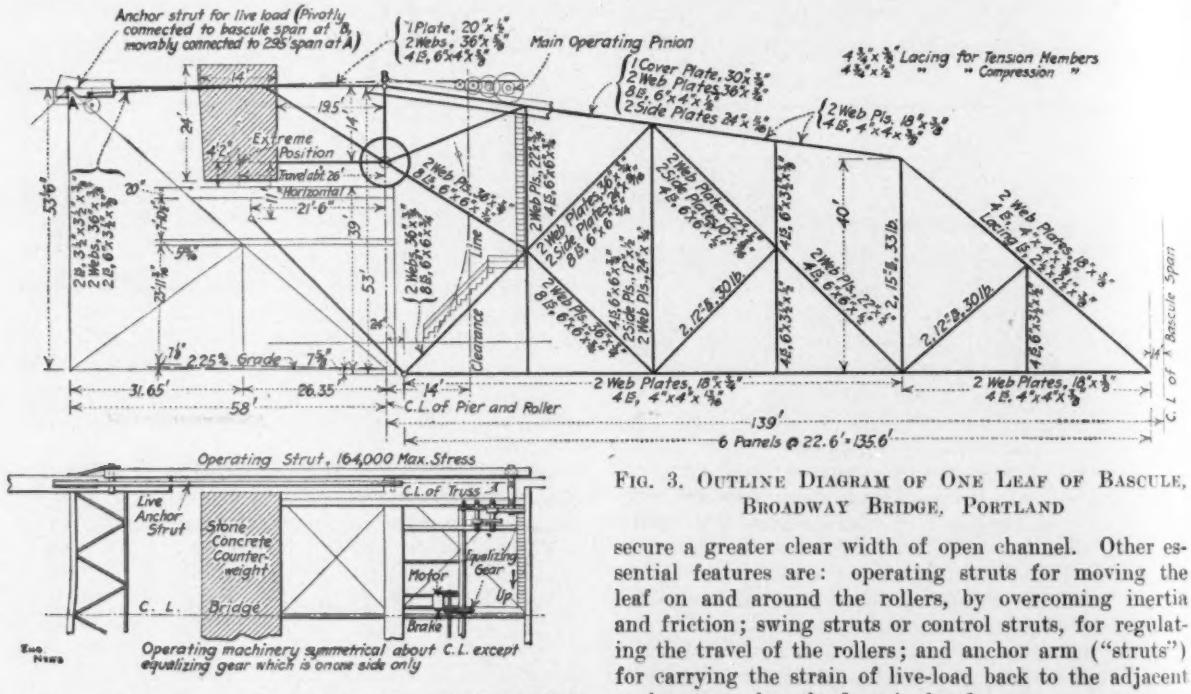

FIG. 3. OUTLINE DIAGRAM OF ONE LEAF OF BASCULE, BROADWAY BRIDGE, PORTLAND

The bascule span of the Broadway bridge has a length of 278 ft. between pier centers and a clearance of 250 ft. between foundations of piers, the latter dimension being required by the U. S. War Department. The two leaves of the span are identical in every respect except for the fact that the locking mechanism is on the west leaf. The weight of structural steel in each leaf is 930 tons, besides which the counterweight attached to the tail or back arm is about 1150 tons. The end posts of the leaves and of the adjacent anchor spans are fully 3 ft. square.

COUNTERWEIGHTS—The concrete used for the counterweight for the west leaf was a 1 : 2½ : 5 mixture, with an average weight of 149.5 lb. per cu.ft. That for the east counterweight was somewhat less rich, although exactly the same size, as the weight desired for the west leaf was about 22 tons more than for the east one, because of the added weight of the locks on the end of the west

*This bid was subsequent to the others, and was prepared and received on the bidder's claim that the original bid was not strictly comparable with the others.

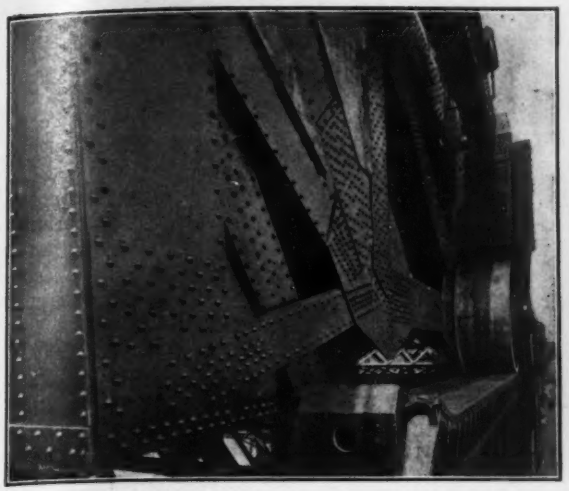

FIG. 4. LOOKING ALONG TRACK, SHOWING 40x100-IN. NICKLE-CHROME STEEL ROLLER
(Anchor "strut" above; counterweight box at left.)

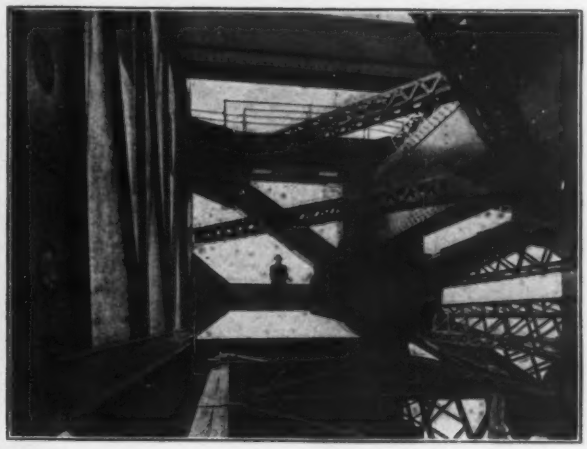

FIG. 5. LOOKING ACROSS AT ROLLER OF OPPOSITE TRUSS
(Operating strut above. Counterweight box at left. Anchor "strut" just back of top chord.)

FIGS. 4 AND 5. TRACK, ROLLERS AND COUNTERWEIGHTS OF THE RALL BASCULE IN THE BROADWAY BRIDGE

leaf. Each counterweight is 44 ft. wide (crossways of the bridge) by 26½ ft. high by 15 ft. average thickness; the actual volume, however, is but 15,550 cu.ft., due to a portion of the room being taken by slots to allow passage of the operating struts, and by pits left in the concrete to allow additional concrete to be added as desired for adjustment. The calculated weight of the counterweight for the west leaf is 2,325,000 lb., and that for the east leaf is 2,281,000 lb. When the leaves are fully up (at an angle of about 89°) the counterweights come within 7 in. of the floor.

ROLLERS—For each truss there is a roller of nickel-chrome-steel, 100 in. diameter and 40 in. in face, which travels on a nickel-chrome-steel track supported by a structural-steel track girder. The ends of the shaft of this roller support all the weight of the half leaf and counterweight. The travel of the roller is about 25½ ft. The track casting is 32¾ ft. long over all, 20 in. high and 40 in. wide, and it weighs 20 tons. The specifications for the nickel-chrome-steel call for an ultimate strength of 102,000 lb. per sq.in., an elastic limit of 52,000 lb. per sq.in., an elongation of not less than 14%, with reduction of 17%. The shaft or axle of the roller is of forged steel and is hollow, the outside diameter being 28 in. and the inside 16 in.

OPERATING STRUTS—Located 12 ft. either side of the longitudinal center line of the leaf is an operating strut attached by a pin at the forward end and reaching back over the anchor span. On the bottom face of this strut is a rack, the teeth of which mesh with those of a pinion which is operated by electric motor through a train of gearing. On top of each anchor span is a small machinery house containing two 75-hp. G. E. motors.

TABULATION OF LOW BIDS ON SUPERSTRUCTURE OF BROADWAY BRIDGE, PORTLAND, ORE.

Item	Rall			Scherzer			Strauss			Strauss Modified		
	Quantities	Unit price	Amount $	Quantities	Unit price	Amount $	Quantities	Unit price	Amount $	Quantities	Unit price	Amount $
Steelwork	13,968,000 lb.	4.01c.	560,116.80	14,245,000	3.94c.	561,253	14,955,000	3.98c.	595,200	14,100,000	4.01c.	565,410
Operating machinery	183,000 lb.	10.15c.	19,215	200,000	10.0c.	20,000	176,000	10.05c.	18,480	171,000	10.05c.	17,955
Electrical machinery	.....	.....	11,200	.....	.....	11,200	.....	.....	11,200	.....	.....	11,200
Royalty (for bascule)	.....	.....	12,000	.....	.....	17,000	.....	.....	17,000	.....	.....	17,000
Creosoted timber (in deck)	666 M ft.b.m.	$50.	33,300	666,000	$50.	33,300	666,000	$50.	33,300	666,000	$50.	33,300
Shuman pavement (on bascule)	1,435 sq.yd.	$3.75	5,381.25	1,435	3.75	5,381.25	1,435	3.75	5,381.25	1,435	3.75	5,381.25
Creosoted wood-block pavement	10,270 sq.yd.	$2.20	22,594	10,270	2.20	22,594	10,270	2.20	22,594	10,270	2.20	22,594
Reinforced-concrete sidewalk and protection slabs	4,433 sq.yd.	$4.70	20,835.10	4,433	4.70	20,835.10	4,433	4.70	20,835.10	4,433	4.70	20,835.10
Counterweights	4,350,000 lb.	0.21c.	9,135	3,290,000	0.27c.	8,883	6,300,000	0.32c.	20,160	5,430,000	0.22c.	11,946
			$693,777.15			$700,446.35			$744,150.35			$705,621.35

NOTE:—All the above bids are by Pennsylvania Steel Co., who were low on each design. The other bidders were Robt. A. Wakefield, Sound Contracting & Engineering Co., and U. S. Steel Products Co. Their bids show about the same difference between the several designs as the Penn. Steel Co. figures.

CONTRACT COST OF SUPERSTRUCTURE OF BROADWAY BRIDGE

Item	Quantity	Unit price*	Cost
Steelwork	15,617,498 lb.	4.01c.	$626,261.67
Operating machinery	137,181 lb.	10.5c.	14,404.00
Electrical machinery	.....	.....	11,200.00
Royalty (for Rall bascule)	.....	.....	12,000
Creosoted timber (in deck)	627,316 ft. b.m.	$50 per M.	31,365
Shuman pavement (on bascule)	1,306.6 sq.yd.	3.75	4,899.75
Creosoted wood-block pavement.	10,115.7 sq.yd.	2.20	22,254.54
Reinforced-concrete sidewalk and protection slabs	5,333.77 sq.yd.	4.70	25,060.72
Counterweights	4,606,342 lb.	0.21c.	9,673.32
Total			757,127.00
Items of extra work			6,253.97
Total payment to Penn. Steel Co.			$763,380.97

* As per Rall bid, see above.

The operating struts are 91 ft. long over all and have a movement of about 65 ft. Owing to the great length and the fact that the strut is cantilevering for most of its movement, the strut proper has a stiffening girder attached to its top side. The stiffener increases in depth from nothing at the front end to 3¼ ft. in 19 ft. distance (making a total depth of strut of 4½ ft.); this depth continues for 26½ ft. and then the stiffener tapers on a straight slope to the tail end. Each strut weighs 21 tons, including its rack casting.

The maximum stress on the rack of each strut is calculated as 200,000 lb., due to a wind pressure of 15 lb. per sq.ft., normal, to the floor for any position of the leaf. If the bridge is operated with no wind pressure against the floor there will be a small rack stress at the starting point from horizontal position of leaf, and it decreases to zero at an angle of 45°, beyond which there is a slight overbalance so that a holding back is required until the leaf is fully up. On lowering the leaf corresponding stresses in the opposite direction arise.

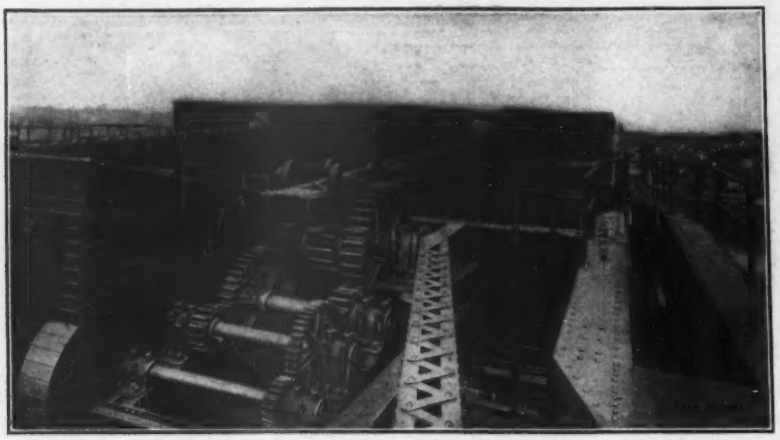

FIG. 6. MACHINERY HOUSE ON ANCHOR SPAN, LOOKING TOWARD BASCULE

(Operating strut, pinion and gearing in center; left-hand operating strut at left. Both operating struts pass through slots in counterweight concrete. At right is the rear end of the anchor "strut," and the space left for its movement.)

The connection of each truss of the leaf with the corresponding truss of the anchor span is by an anchor "strut" (more properly an anchor *tie*). This is a slotted girder 52 ft. long, with a travel of about 35 ft. The distance between centers of pins is 46½ ft. The two struts have to take the strain in tension due to the entire live-load that comes on the leaf. Each strut is attached to the end of the upper chord of the leaf by a 13-in. pin, and to an extension of the end of the upper chord of the fixed span by a 10½-in. pin. The slot of the strut passes over the latter pin when the leaf is in motion, and, by an adjustment, the semicircular end of the slot comes exactly against the fixed pin when the leaf is down, so that the strain due to the live-load is fully taken. Within the slot is placed a hydraulic buffer, so adjusted as to be brought into action when the bearing reaches to within about 2½ ft. of the pin, so that the pin is brought to its seat very gently. As the upper chord connections come to a bearing the end of the lower chord of the leaf, by means of a heel casting or socket, comes to a bearing against a casting set in the end of the bottom chord of the fixed span, thus taking the compression due to the live-load.

SWING STRUTS—A controlling strut or link is provided for each truss, having one end attached to a pin on the inside of the track girder, and the other end pinconnected to the counterweight box. The link is 23 ft. long between centers of pins, and swings through an arc of about 105°. The pin in the counterweight thus describes a true circular curve, but all other parts of the leaf describe varying curves.

MACHINERY—The operating machinery (proper) is located on top of each fixed span, near its end next to the bascule. Two 75-hp. G. E. 600-volt motors running at a speed of 650 r.p.m. act together, or singly, through a train of gearing by which about five multiplications of power are secured, and rotate two main pinions (one for each operating strut) whose teeth mesh with those of the rack on the under side of the strut. The rack and pinion are held in mesh (for those positions where the weight of the strut does not suffice to hold it down) by two small rollers or sheaves on each side of the pinion, which have a bearing on the outside flanges of the strut and are held in place by arms reaching to a pin connection below the pinion.

Friction brakes are used for control of the machinery, and in the normal position these are kept applied by weighted lever-arms; the brakes are released by the raisator. For locking the ends of the two leaves together rigidly

For locking the ends of the two leaves together rigidly when they are down, there is located under the end of the floor of the west leaf a pair of lock bolts, which when shot enter sockets on the east leaf. The locks are driven by a 5-hp. motor, also under the floor, which is controlled from the operator's tower.

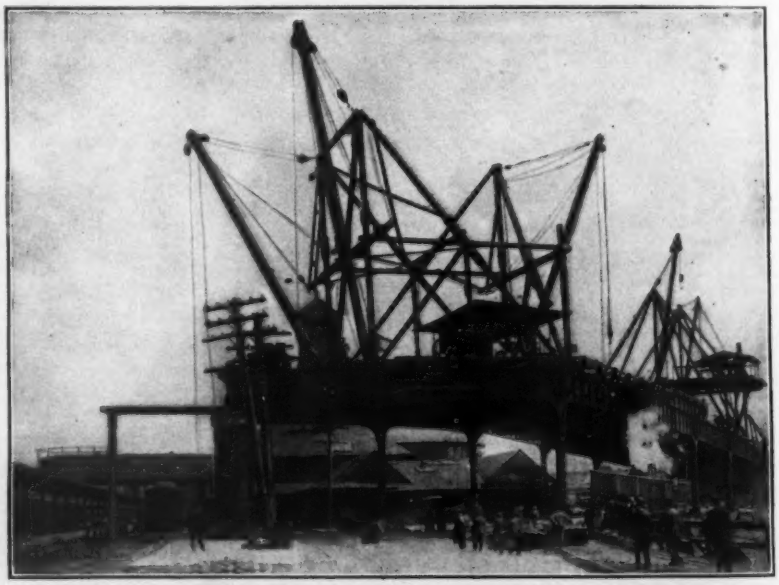

FIG. 7. ERECTION OF WEST APPROACH, BROADWAY BRIDGE

(Erection traveler in center; yard traveler at right.)

There is an operator's tower on each anchor span, on the upstream side for the east span and on the downstream side for the west span. Both leaves can be operated from the west tower, but only the east leaf from the east tower. Each tower is fully supplied with switches, controlling and indicating devices, by which entire control is obtained of the movement and locking of the leaves and of the setting of signals for bridge traffic and river traffic. The movement of the leaf is in full view of the operator, in addition to which a series of electric lamps indicates various positions of the leaf. Red and green lights are shown to river traffic by an automatic arrangement connected with the leaf, indicating the closed and open position.

Erection

The erection of the superstructure involved some features of more than usual interest.

West Side—For all the bridge west of the channel the procedure was as follows: An erection traveler moved on rails laid on temporary ties on the steel stringers. This traveler (sometimes called a mule traveler and sometimes called a two-boom gantry) was a square traveler, as it had two booms in front, but it also had an additional boom in the rear. Of the front booms, one had a length of 80 ft. and a reach (in operation) of 60 ft., with a capacity of 25 tons, while the other one was of 15 tons capacity, and both were operated with steel cable. There was also a 10-ton rear boom placed on one corner; this one was operated with manila rope.

Material was delivered to the erection traveler by a yard traveler, which had a 25-ton front boom in front and a 10-ton rear boom capacity in the rear. This traveler, which was as wide as the roadway (46 ft.), traveled on a track formed by a rail along the top of each of the two lines of girders. As the west approach is along railway yards, and there was already a siding along one side of the bridge site, the delivery of material was quite direct; the sidewalks were left off until the material was all unloaded from cars. The yard traveler was built so as to leave a clear space of about 18 ft. above the floor of the viaduct, the boom and other machinery being supported by truss-work spanning the viaduct (this for the purpose of affording storage space underneath for the material to be used at the front). The traveler hoisted the material from the cars as it was delivered and deposited it at different places along the deck of the viaduct, to stay until called for at the front by the erection traveler.

Material was delivered at the front by home-made 4-wheel cars, running on a standard-gage track on the right or easterly side of the bridge. These cars were hauled by lines running from the hoisting engines on the erection traveler to sheave blocks near the front of the work. The cars passed each other not by sidings but by hoisting the empty one up in the air and allowing the loaded one to pass underneath.

The yard traveler had capacity to handle all the members of the bridge, except for some going in the bascule span and in the nearer ends of the anchor spans adjoining. These members (13 for each side of the bridge) weighed from 27 to 40 tons each. For the west side these pieces were handled by a derrick set on the bridge deck on the outside of the bend, working together with the yard traveler at this point. The latter took the heavier end and the derrick the lighter one.

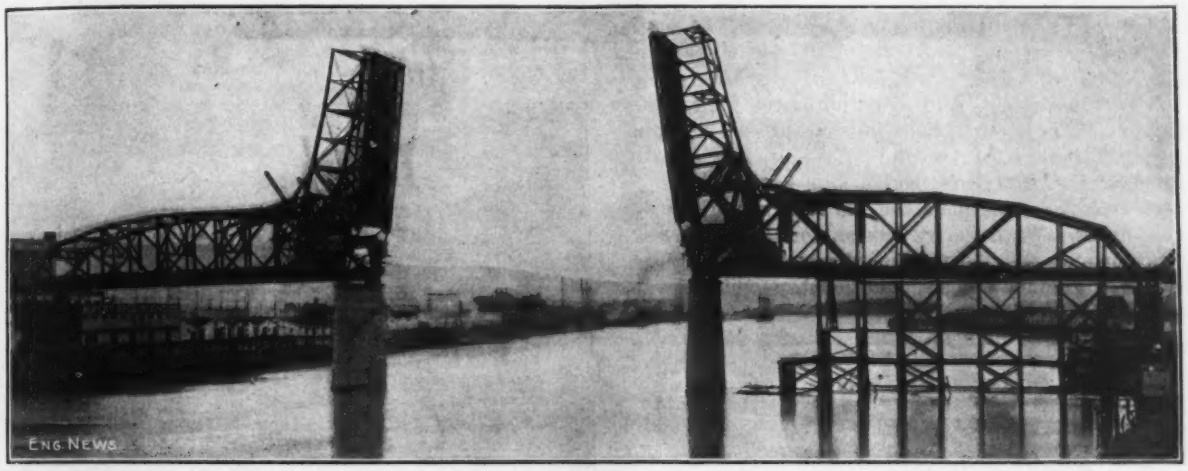

Fig. 8. Bascule of Broadway Bridge, Open

(View looking downstream. In right span some of the false work is still in place. Anchor "struts" of bascule are seen projecting diagonally upward back of right leaf. The tapering operating struts are just below, projecting back into the fixed span, slightly downward.)

The west leaf of the bascule span was erected in the open position, standing at about 80° from the horizontal. A specially designed single-boom traveler of 30 tons capacity was used. This traveler was hoisted up along the top chords of the leaf and anchored to the same in different positions as the work progressed. Most of the material had to be swung clear outside of the trusses of the anchor span to clear the completed work. The delivery to the traveler was made by the small cars running on temporary track on the sidewalk.

East Side—For erection of the east anchor span the regular erection traveler was transferred from the west side. On the east side the bascule leaf was built with an erection traveler like that on the west side, but all material except that for the shore span was hoisted directly from barges in the river. In this way, as the hoisting was from directly in front of the traveler, both of its booms could be used together, so that the combined

capacity of 40 tons was sufficient for the largest pieces.

For all of the truss spans except the bascule, falsework was used in the regular way. Framed bents were used on the dry land, but for both anchor spans and most of span No. 3, piles were necessary. A separate line of timber bents was used for each truss, except in the river, where they were braced together. A bent consisted of four posts, 10x12- or 12x12-in. Where practicable one bent was placed under each panel-point, but across the railway yards the position had to be varied to clear the tracks.

For the anchor spans 13-pile bents were used, except that 19-pile bents were provided at the panel-points where the front part of the erection traveler would come when handling 40-ton pieces. The pile bents were capped at a suitable point above the water and framed bents tapered above to the under side of the trusses.

The placing of the Shuman paving or flooring on the bascule span was mostly done while the leaves were still under erection, so that it was put on while the position was about 80° from the horizontal. The sections were hoisted up to two workmen by helpers working on the pier, and were then put in position and toe-nailed to the subplanking.

The counterweights were built up as the work on the bascule leafs progressed, the aim being to keep the counterweight slightly over weight. As additional security, post braces of 16x16-in. timbers were kept in place between the tops of the piers and the underside of the uplifted leaves. When the structural work on the bascule was completed and the machinery installed, the adjustment was gradually made, additional weights of railroad rails being placed at the ends of the leaves pending completion of the Shuman paving.

Time and Personnel

Preliminary work for erection of the superstructure was begun about Apr. 1, 1912. The bridge was thrown open to traffic on Apr. 22, 1913.

The Broadway Bridge was designed and built under the supervision of Ralph Modjeski, M. Am. Soc. C. E., of Chicago. The bascule span was designed by the Strobel Steel Construction Co., of Chicago. The resident engineer immediately in charge of construction for Mr. Modjeski was W. R. Weidman for the substructure work, and H. M. Harps for the superstructure. The contract work on the substructure was done by the Union Bridge & Construction Co., of Kansas City, Mo., with Thos. Alexander in charge as their engineer. The superstructure was fabricated and erected by the Pennsylvania Steel Co., of Steelton, Pa., with H. E. Trout as their engineer in charge. To the gentlemen named, and also to the Strobel Steel Construction Co., of Chicago, the writer is indebted for information from which this article has been prepared.

The total cost of the bridge to the city, counting all the items of expense, was about $1,600,000.

A Benzol-Electric Motor Train has been built for the Khedive of Egypt by the Metropolitan Railway Carriage & Finance Co., of Birmingham, England. The train consists of two cars, each of which is equipped with electric motors on their trucks. Current for operating the motors is furnished by a direct-current generator driven by a 100-hp. benzol engine. This generating plant is carried on a truck with long wheel base which runs in advance of one of the cars.

An Economical Wharf-Bulkhead

By Wm. M. Torrance*

In Savannah, Ga., there has recently been put into commission a novel bulkhead-wharf constructed of reinforced concrete on timber piling.

The harbor at Savannah is inland, the city being located on the Savannah River, some 17 miles from its mouth; the waters, while subject to the tides, are fresh and without teredo or other timber destroying agents, hence unprotected timber piling is properly available for use.

Fig. 1 is a view from the waterfront of the bulkhead as now finished; and Fig. 2, showing the details of construction, is taken from the drawing accompanying the U. S. patent granted to the writer and to Wayne Cunningham on this type of construction, July 22, 1913. The patent drawing was made up from the working drawings of the Savannah bulkhead.

Referring to Fig. 2, the following extracts from the patent specifications are self-explanatory:

As shown on this patent drawing, the bulkhead is supported on piles which may be of wood, concrete or other suitable material and which are driven into or set in the bed

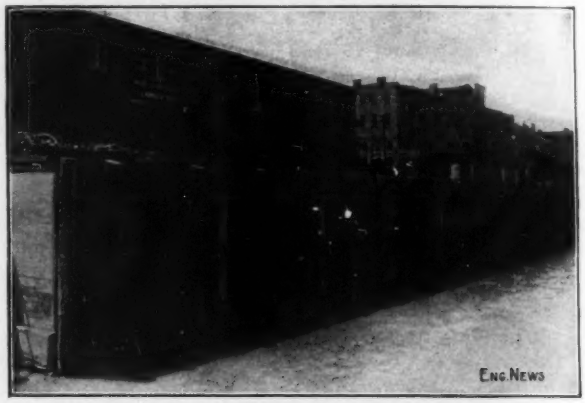

Fig. 1. Wharf-Bulkhead of Special Type on Savannah River

of the harbor. This piling is so arranged as to support a system of deck-supporting walls which run substantially at right angles to the bulkhead line from rear to front of the structure. These walls in turn support a deck which is so constructed as to carry the superimposed load of earth and paving, forming the paved area of the wharf, together with the merchandise or other load material which is to be supported by the wharf safely from wall to wall of the series of walls.

An important feature of this invention is the downward inclination of the deck toward the rear, which inclination is given thereto in order to eliminate any tendency on the part of the bulkhead to slide forward because of the weight of the superimposed material. This downward inclination to the rear is always less than the angle of repose of the filling material when the same is loaded. With a deck so constructed there will be practically no tendency upon the part of the bulkhead to move forward or toward the water with the load in position; but in order to safeguard the bulkhead against any such tendency, however slight in degree, inclined or battered piles are provided. The upper ends of these piles support a chock beam which extends along and within the back wall of the deck; and the piles are so driven that they do not encroach in the least upon the depth of clear water immediately in front of the bulkhead.

In order to prevent a boat when coming alongside the bulkhead from rubbing against the forward ends of the deck-supporting walls or the front edge of the deck, there are

*Consulting Engineer, 123 William St., New York City.

provided fender piles which are suitably fastened to horizontal beams, forming thereby a fender system. At the front edge of the deck a curb is provided for confining the pavement of the wharf. In rear of the back wall of the deck, sheet piling is driven for the purpose of retaining the earth in case the river-bed should change..

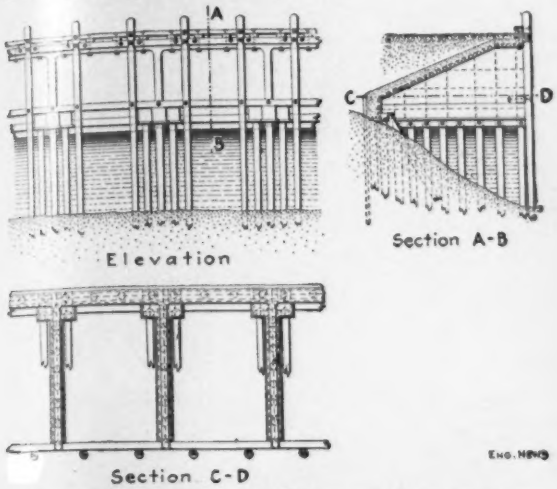

FIG. 2. DETAILS OF THE TORRANCE-CUNNINGHAM WHARF-BULKHEAD

Projecting forwardly from the rear wall of the deck and formed integral therewith are concrete caps which lie above the upper ends of the battered piles. The deck is reinforced.

As hereinbefore stated the inclination to the horizontal of the main portion of the top of the deck is less than the angle of repose of the filling material when loaded with the paving or other roadbed material, from which it results that the filling will rest on the deck with substantially no tendency to slip and with only the vertical gravity resultant force coming into play or acting against the deck.

The transverse reinforcing members give stiffness and stability to the structure and to prevent buckling of the same in case the structure is subjected to forces acting in the direction of the bulkhead line, such as the stresses occasioned by the striking or rubbing of vessels in coming alongside the structure.

The deck-supporting walls may be omitted and the piles (in this case preferably of concrete or in the form of concrete columns) extended upward until they take the load off and support the deck; or other suitable ways of supporting the deck may be provided.

The writer believes that this construction is an improvement over anything now in general use as a standard bulkhead, its advantage being the comparative rigidity and economy obtained in an absolutely permanent structure.

Fig. 3 is a progress view showing the method employed in making and placing forms on this Savannah work. It is thought that for a long construction by this plan a collapsible form for each pocket could be used, and after each use these could be released from the concrete and moved forward into the channel on a raft or by other flotation means and the completed form for another pocket again floated into position. Such repetition as this was proposed by the writer for the Savannah work, but there being but ten pockets in the work it was not considered that it would pay, and what repetition was secured in the use of form lumber was done by the re-use of individual pieces of lumber.

FIG. 5. COMPLETED BULKHEAD BEFORE BACKFILLING

Fig. 4 shows a portion of the deck concreted; forms ready and reinforcing steel ready for another portion; and form work in progress in the foreground. Fig. 5 is a view of the practically completed bulkhead, without the filling, taken from the rear.

SUMMARY AND COST DATA

Total length of bulkhead, 155 lin.ft.

Total concrete in job, 283 cu.yd.—cost $10.20 per cu.yd., including forms and reinforcement.

Hardware used in permanent work, $21.30.

Bearing and batter piles in job, 164—cost furnished, driven and cut off, $8.50 per pile.

Fender piles in job, 25—cost furnished, driven and cut off, $8.50 per mile.

Sheet piling behind and at ends, 171 lin.ft., 14.7 M. Cost in place, $38 per M.

Structural lumber in permanent construction (except sheet piling), 12 M.—Cost in place, $40 per M.

The above named unit costs do not include any costs for engineering plans and superintendence (which three

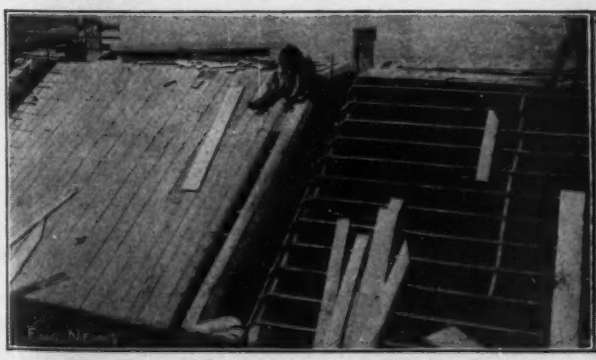

FIG. 3. PLACING FORMS FOR BULKHEADS

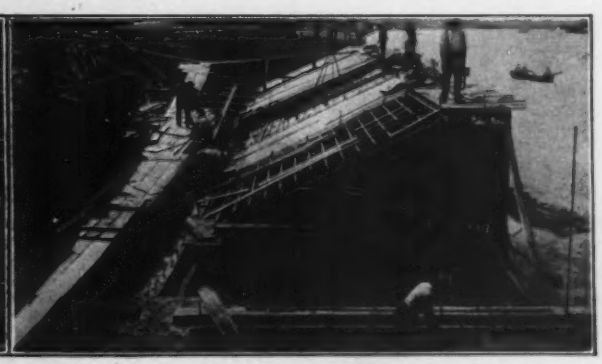

FIG. 4. SAVANNAH CONCRETE BULKHEAD UNDER CONSTRUCTION

items would total about $850 for the job). Neither do they include any contractor's profit, being the actual unit costs to the contractor. Neither do they include any patent royalties.

The filling above the deck of the bulkhead was done by the owner after the completion of contract, and cost very little.

The work described was accomplished during the summer of 1912. The work was executed by the Savannah Engineering and Construction Co., of Savannah, Ga. (Wayne Cunningham, President), for the Standard Fuel Supply Co., of Savannah, Ga., at the foot of Lincoln St., in that city, from designs by the writer, acting as engineer for the contracting company.

The Rating of Current Meters

By J. B. Brown*

The extensive use of current meters by the California Development Company since the appointment of W. H. Holabird as Receiver, and the necessity for accurate ratings of the same, was brought out in an article prepared by J. C. Allison, Assistant General Manager and Chief Engineer for the Receiver, entitled "Seiling Water by Current-Meter Measurement," appearing in Engineering News of Jan. 9, 1913. This article is a description of the method used for rating current meters at the station named and is based on the work of the author.

As described in the above-named article, the rating station consists of a concrete-lined flume, 175 ft. in length, over which the rating car is operated. The rating car is a combination of a flat car and an automobile and is equipped with a 3-hp. variable-speed motor. Speed control is provided for by means of the transmission and gears of an old automobile.

In taking observations the car is run at speeds of approximately ½, 1, 1½ and 3 ft. per sec. Usually, ten observations are taken at each speed. The observations recorded are: (1) Number of revolutions of the meter; (2) distance traveled; (3) time in seconds for each run.

It has been found by experience that a meter recording single revolutions will give approximately 40 revolutions when drawn through the water for a distance of 100 ft. In the case of penta-meters, or those recording each fifth revolution, 45 revolutions will be given in the same distance. Time is taken by means of a stop watch. Distances are observed by means of a pointer on the car as it traverses marked stations at each end of the run. The zeros of the marked stations are exactly 100 ft. apart with plus (+) and minus (−) distances marked each way from the zeros for a distance of 14 ft.

The observations are worked up according to the accompanying form, shown as Fig. 2. Values of X and Y may be computed by any convenient method such as long division, use of logarithms or the use of reciprocals. A convenient method of performing these operations is to use the reciprocals of the values of the time (column 3) and multiply them by the number of revolutions, as given in column 2, for the values of X, and by the distance, as given in column 4, for the values of Y.

In taking the mean of Summation X and Summation Y, any remainder after performing the division should be retained as a means of checking the subtractions of Xo from X, and Yo from Y. These subtractions will give *plus* (+) and *minus* (−) quantities on either side of the mean value of Xo and Yo. An example follows:

Summation X = 26.0823

$Xo = 0.6521$ $\quad Xo = \frac{\text{Summation X}}{n} = \frac{\text{Summation X}}{40}$

40 × 0.6521 = 26.0840

26.0840 − 26.0823 = 0.0017, Remainder Correction, i.e., 0.0017 is added to dividend to make last figure of quotient a whole number.

Summation Y = 62.4048

$Yo = 1.5601$ $\quad Yo = \frac{\text{Summation Y}}{n} = \frac{\text{Summation Y}}{40}$

40 × 1.5601 = 62.4040

62.4048 − 62.4040 = −0.0008, Remainder Correction, i.e., 0.0008 is subtracted from dividend to make the last figure of quotient a whole number.

It will be observed that the first 20 values of X are less than the mean and that the last twenty are greater than the mean; hence, $X - Xo$, as shown in column 7, will be negative for the first 20 values and positive for the last 20. The same applies to the values of $Y - Yo$, column 8.

Fig. 1. Current-Meter Rating Car and Flume

These subtractions are conveniently checked by means of the Remainder Correction:

Sum of negative values of X − Xo =	−6.3630
Sum of positive values of X − Xo =	+6.3613
Algebraic difference,	−0.0017
Remainder correction,	+0.0017
Sum =	0.0000 (Check)
Sum of negative values of Y − Yo =	−14.7671
Sum of positive values of Y − Yo =	+14.7679
Algebraic difference,	+ 0.0008
Remainder correction,	− 0.0008
Sum =	0.0000 (Check)

The quantities of U^2 and UZ are formed in any convenient way such as tables of squares, logarithms or by Crelle's Rechtentafeln. It will be seen that the equation to be developed from the residuals U and Z is a straight-line equation of the form,

$$y = ax + b$$

*1418 13th St., Sacramento, Calif.

METER Nº 1480

Description: Small Price - Rod. Date Rated: April 12, 1913.
Last used by: New Instrument. Observations by: J. B. Brown.
Electricity Used: [illegible] Time Observations: 2 hrs.
Equipment: Code (Saville Telephone. Time Computing: 12 hrs.
Equation: V=2.3281R+0.0420 Total 14 hrs.

Run	Rev. No.	Time in Sec.	Distance in Feet	X Rev. per Sec.	Y Ft. in 1 Sec.	U X−Xo	Z Y−Yo	U²	UZ
1	40	142	99.5	0.2817	0.7007	-0.3104	-0.8594	0.1372	0.3183
2	"	137	96.5	0.2920	0.7044	0.3601	0.8557	0.1297	0.3081
3	"	144	100.5	0.2778	0.6979	0.3743	0.8622	0.1401	0.3227
4	"	137	97	0.2920	0.7081	0.3601	0.8520	0.1297	0.3068
5	"	140.5	99	0.2847	0.7047	0.3674	0.8554	0.1350	0.3143
6	"	138.5	98	0.2888	0.7076	0.3633	0.8525	0.1320	0.3097
7	"	141	99.5	0.2837	0.7057	0.3684	0.8544	0.1357	0.3148
8	"	139	97.5	0.2878	0.7014	0.3643	0.8587	0.1327	0.3128
9	"	141	100	0.2837	0.7092	0.3684	0.8509	0.1357	0.3135
10	"	139	97.5	0.2878	0.7014	0.3643	0.8587	0.1327	0.3128
11	"	104	97	0.3846	0.9327	0.2615	0.6274	0.0716	0.1678
12	"	105.5	99	0.3792	0.9384	0.2729	0.6211	0.0745	0.1697
13	"	104	98	0.3846	0.9423	0.2675	0.6178	0.0716	0.1653
14	"	106.5	100	0.3756	0.9390	0.2765	0.6211	0.0764	0.1717
15	"	103	99	0.3810	0.9429	0.2711	0.6172	0.0735	0.1673
16	"	104	97.5	0.3846	0.9375	0.2615	0.6226	0.0716	0.1665
17	"	105	99	0.3810	0.9429	0.2711	0.6172	0.0735	0.1673
18	"	105	98.5	0.3810	0.9381	0.2711	0.6220	0.0735	0.1686
19	"	104.5	98.5	0.3828	0.9425	0.2693	0.6176	0.0725	0.1663
20	"	104	97.5	0.3846	0.9375	-0.2675	-0.6226	0.0716	0.1665
21	"	96.5	95.5	0.7080	1.6903	+0.0559	+0.1302	0.0031	0.0073
22	"	97	93	0.7018	1.6667	0.0497	0.1066	0.0025	0.0053
23	"	98	96	0.6896	1.6551	0.0375	0.0950	0.0014	0.0036
24	"	97	93.5	0.7018	1.6404	0.0497	0.0803	0.0025	0.0040
25	"	97.5	95	0.6956	1.6521	0.0435	0.0920	0.0019	0.0040
26	"	98	95.5	0.6896	1.6465	0.0375	0.0864	0.0014	0.0032
27	"	97.5	95	0.6956	1.6521	0.0435	0.0920	0.0019	0.0040
28	"	98	95	0.6896	1.6379	0.0375	0.0778	0.0014	0.0029
29	"	97.5	94.5	0.6956	1.6434	0.0435	0.0833	0.0019	0.0036
30	"	98	96	0.6896	1.6651	0.0375	0.0950	0.0014	0.0036
31	"	31.5	94	1.2698	2.9841	0.6177	1.4240	0.3816	0.8796
32	"	33	96	1.2121	2.9091	0.5600	1.3490	0.3136	0.7554
33	"	31	92.5	1.2903	2.9839	0.6382	1.4238	0.4073	0.9087
34	"	32.5	94	1.2308	2.8923	0.5787	1.3322	0.3349	0.7709
35	"	31.5	94.5	1.2698	3.0000	0.6177	1.4399	0.3816	0.8894
36	"	32.5	95.5	1.2308	2.9384	0.5787	1.3783	0.3349	0.7976
37	"	32	94	1.2500	2.9375	0.5979	1.3774	0.3573	0.8235
38	"	32.5	95.5	1.2308	2.9384	0.5787	1.3783	0.3349	0.7976
39	"	32	94	1.2500	2.9375	0.5979	1.3774	0.3573	0.8235
40	40	33	96	1.2121	2.9091	+0.5600	+1.3490	0.3136	0.7554

$X_o = \Sigma X/40$ $\Sigma X = 26.0823$ $\Sigma Y = 62.4048$ $\Sigma U = 1.5601$ $\Sigma UZ = 13.0539$
$Y_o = \Sigma Y/40$ $X_o = 0.6521$ $Y_o = 1.5601$

Log ΣUZ = 1.1157403 $\Sigma UZ = a$ = Slope
Colog ΣU^2 = 9.2512540 0.7487460 ΣU^2
Log a = 0.3669943 a = 2.32806 = Slope $Y_o - aX_o = b$ = Intercept.
Log X_o = 9.8143142 Y_o = 1.5601
Log aX_o = 0.1813085 $-aX_o$ = 1.5181 $V = 2.3281R + 0.0420$
b = 0.0420 = Intercept

FIG. 2. COMPUTATION TABLE FOR CURRENT METER, CALEXICO, CALIF.

(Original sheet, 8½x11 in. overall.)

X = Revolutions per second, obtained by dividing number of revolutions by the time in seconds.
Y = Velocity in feet per second, obtained by dividing distance by time.
U = Values of X — Xo, Xo being the mean of all the values of X.
Z = Values of Y — Yo, Yo being the mean of all the values of Y
U^2 = Values of U^2.
UZ = Product of U and Z, or results of columns 7 and 8.

The Slope Coefficient a is determined by dividing Summation UZ by Summation U^2. The Intercept Constant is determined by substituting values of Xo and Yo in the standard straight-line equation,

$$y_o - ax_o = b = Intercept$$

In plotting the above equation (Fig. 3) it is convenient for filing purposes to have the height of the sheet equal to that of a standard letterhead, and the length may be any convenient unit as any excess can be folded in. Since the values of Y increase more rapidly than the values of X, it is convenient to let the horizontal axis denote values of Y and the vertical axis the values of X.

The rating table sent out to the hydrographers (Fig. 4) is conveniently computed on an adding machine having a "Sub-Total" lever. The increments on the rating table vary by hundredths of revolutions per second, hence by taking the equation as developed above and first setting down the intercept (b) and then adding 0.01 of the slope coefficient, the first value of the velocity with respect to the number of revolutions per second is obtained. By adding 0.01 of the slope coefficient and taking the sub-total each time, the whole table is developed. An example follows:

W H HOLABIRD AS RECEIVER
THE CALIFORNIA DEVELOPMENT COMPANY
WATER DEPARTMENT

RATING TABLE FOR METER No. 1480

From observation made April 12, 1913 at the rating station at Calexico, California
by J. B. Brown, Hydrographer, Computations made by J. B. Brown, Hydrographer
Description of Meter Small Price - with Rod
Used last by New Instrument, not in use heretofore Rivers
Hand test at rating: Head well oiled, ran Seconds; Revolutions

Rev. per Sec.	Vel. per Sec.	Rev. per Sec.	Vel. per Sec.	Rev. per Sec.	Vel. per Sec.	Rev. per Sec.	Vel. per Sec.	Rev. per Sec.	Vel. per Sec.	Rev. per Sec.	Vel. per Sec.	Rev. per Sec.	Vel. per Sec.	Rev. per Sec.	Vel. per Sec.	Rev. per Sec.	Vel. per Sec.
0.01	0.06	0.21	0.53	0.41	0.99	0.61	1.46	0.81	1.93	1.01	2.39	1.21	2.86	1.41	3.32	1.61	3.79
0.02	0.09	0.22	0.55	0.42	1.02	0.62	1.48	0.82	1.95	1.02	2.41	1.22	2.88	1.42	3.35	1.62	3.81
0.03	0.11	0.23	0.58	0.43	1.04	0.63	1.51	0.83	1.97	1.03	2.44	1.23	2.90	1.43	3.37	1.63	3.83
0.04	0.13	0.24	0.60	0.44	1.06	0.64	1.53	0.84	2.00	1.04	2.46	1.24	2.93	1.44	3.39	1.64	3.86
0.05	0.16	0.25	0.62	0.45	1.09	0.65	1.55	0.85	2.02	1.05	2.48	1.25	2.95	1.45	3.42	1.65	3.88
0.06	0.18	0.26	0.65	0.46	1.11	0.66	1.58	0.86	2.04	1.06	2.51	1.26	2.97	1.46	3.44	1.66	3.90
0.07	0.20	0.27	0.67	0.47	1.13	0.67	1.60	0.87	2.07	1.07	2.53	1.27	3.00	1.47	3.46	1.67	3.93
0.08	0.23	0.28	0.69	0.48	1.16	0.68	1.62	0.88	2.09	1.08	2.55	1.28	3.02	1.48	3.49	1.68	3.95
0.09	0.25	0.29	0.72	0.49	1.18	0.69	1.65	0.89	2.11	1.09	2.58	1.29	3.04	1.49	3.51	1.69	3.97
0.10	0.27	0.30	0.74	0.50	1.20	0.70	1.67	0.90	2.14	1.10	2.60	1.30	3.07	1.50	3.53	1.70	4.00
0.11	0.30	0.31	0.76	0.51	1.23	0.71	1.69	0.91	2.16	1.11	2.62	1.31	3.09	1.51	3.56	1.71	4.02
0.12	0.32	0.32	0.78	0.52	1.25	0.72	1.72	0.92	2.18	1.12	2.65	1.32	3.11	1.52	3.58	1.72	4.04
0.13	0.34	0.33	0.81	0.53	1.27	0.73	1.74	0.93	2.21	1.13	2.67	1.33	3.14	1.53	3.60	1.73	4.07
0.14	0.37	0.34	0.83	0.54	1.30	0.74	1.76	0.94	2.23	1.14	2.69	1.34	3.16	1.54	3.63	1.74	4.09
0.15	0.39	0.35	0.85	0.55	1.32	0.75	1.79	0.95	2.25	1.15	2.72	1.35	3.18	1.55	3.65	1.75	4.11
0.16	0.41	0.36	0.88	0.56	1.34	0.76	1.81	0.96	2.28	1.16	2.74	1.36	3.21	1.56	3.67	1.76	4.14
0.17	0.44	0.37	0.90	0.57	1.37	0.77	1.83	0.97	2.30	1.17	2.76	1.37	3.23	1.57	3.70	1.77	4.16
0.18	0.46	0.38	0.92	0.58	1.39	0.78	1.86	0.98	2.32	1.18	2.79	1.38	3.25	1.58	3.72	1.78	4.18
0.19	0.48	0.39	0.95	0.59	1.41	0.79	1.88	0.99	2.34	1.19	2.81	1.39	3.28	1.59	3.74	1.79	4.21
0.20	0.51	0.40	0.97	0.60	1.44	0.80	1.90	1.00	2.37	1.20	2.83	1.40	3.30	1.60	3.76	1.80	4.23

Equipment accompanying this meter consists of -

Rating Curve
$V = 2.3281 R + 0.042Q$

Approved J. C. Pick
Supt. Valley Division.

Calexico, California

Eng. News

FIG. 4. RATING TABLE FOR CURRENT METER, CALEXICO, CALIF.

(Original sheet, 8x11 in., in printed form, with blanks filled in on typewriter, including entries in columns headed "Velocity per Second.")

$$V = 2.3281\,R + 0.042000$$

0.042000
+0.023281

0.01 = 0.065281 s
+0.023281

0.02 = 0.088562 s
0.023281

0.03 = 0.111843 s
0.023281

0.04 = 0.135124 s
Etc.

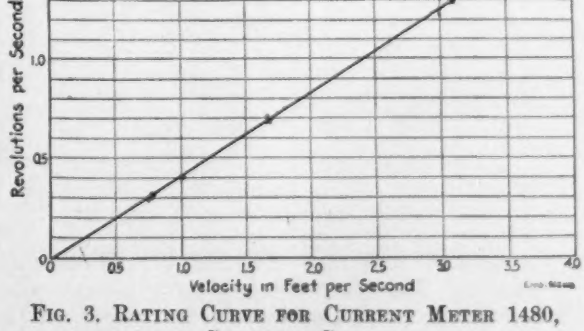

FIG. 3. RATING CURVE FOR CURRENT METER 1480, CALEXICO, CALIF.

(Observations and computations by J. B. Brown. Equations: Algebraic, V = 2.328 (R + 0.0420; graphic, V = 2.33 R + 0.04).

The table shown was computed in this manner and for convenience in the field the last four decimal places were dropped, figuring to the nearest hundredth only.

A Practical Chart for Determining the Horsepower of Spur Gears

By Frederic W. James*

Since their publication in 1893, the Wilfred Lewis formulas for strength of gear teeth have come to be more and more widely accepted by engineers as a national standard of gear design; until, at the present, they have practically displaced all other formulas. This has been accomplished in the face of two grave defects in the formulas, well known and appreciated by all who use them: First, the extreme complication of the operation due to the many variables, three of which are implied functions requiring separate operations to determine their values before the general formula can be applied; second, the formula is irreversible, there being no way of working back from the horsepower and speed to find the necessary size of gear—the more general problem confronting the designer.

There is a strong tendency in the engineering field today to substitute charts on which the mechanical work of calculation has already been performed, for the actual performance of the calculation in problems of this kind. The object is to minimize the amount of mental effort. This tendency has found expression in several published gear charts, but none that have come to the writer's notice seem simple enough for practical use. Some indeed are more troublesome to use than the formula, and none pay due attention to the psychology of the problem. Dr. Barth has devised an ingenious calculator, but this is a special device, not readily filed in the desk book. Facing this real need for a simple and comprehensive gear chart, the writer has analyzed the published data of the Lewis formula, modifying it as discussesd below, and from it devised the accompanying diagram.

Notation:

d = diameter in inches;
f = face;
p = circular pitch in inches;
r = revolutions per minute;
t = number of teeth;
v = pitch velocity, ft. per min.;
h = horsepower of gear;
w = load on one tooth;
y = factor for shape of tooth;
s_i = safe stress for iron gears;
s_s = safe stress for steel gears.

The Lewis formula is

$$h = 0.000007933\ dspfyr \qquad (1)$$

Now assume that $h = m\,n$ where

$$m = 0.000007933\ drs \qquad (2)$$

$$n = pfy \qquad (3)$$

The Factor M

For s, Mr. Lewis gives the values in Table I

v =	100	200	300	600	900	1200	1800	2400
s_i =	8,000	6,000	4,800	4,000	3000	2400	2000	1700
s_s =	20,000	15,000	12,000	10,000	7500	6000	5000	4300

From an inspection of this table we see that $s_s = 2.5\ s_i$ so that we may base all our calculations on iron gears and convert the resulting data into steel by direct multiplication.

The writer has failed to find any simple formula for these stresses. Plotting them on a logarithmic grid as shown in Fig. 1, we note at once that six of the eight correspond closely to the formula $sv^{\frac{1}{2}} = 83{,}000$. The exceptions are the values: $v = 600$, $s = 4000$ where the formula gives 3400, and $v = 900$, $s = 3000$ and the formula 2800. The first error is 18% above the formula, the second 7%; the formula is safe in both cases. It is noteworthy that this discrepancy occurs in the two middle values; the three points at each end show close adherence to the formula.

$$m = 0.000007933\ drs \qquad (2)$$

$$s = 83{,}000\ v^{-\frac{1}{2}}$$

$$dr = \frac{12\,v}{\pi}$$

$$m = 2.515\ v^{\frac{1}{2}} = 1.29\ d^{\frac{1}{2}}r^{\frac{1}{2}} \qquad (4)$$

The Factor N

It is necessary to determine the relation between p and f. A diagram could be constructed to give the horsepower per inch of face, but that would necessitate performing the multiplication after reading the chart. It seems more desirable to read directly the performance of a gear of standard proportions. There is no fixed ratio between face and pitch, but common practice seems to make f about 3 p. It is certain that no additional strength is won by the use of wider faces; only the wear is lessened. For wider faces, then, the power will be the same; for narrower faces it should be reduced by multiplying by the ratio of the faces:

$$h_1 = h\frac{f_1}{f} = h\frac{f_1}{3\,p}$$

On this basis formula (3) may be written:

$$n = 3p^2y \qquad (5)$$

The gears in most general use have the proportions of the 15° involute series, the middle group given by Mr. Lewis for which he gives the factor:

$$y = 0.124 - \frac{0.684}{t}$$

$$\text{but } t = \frac{\pi d}{p}$$

$$y = 0.124 - \frac{0.684\,p}{\pi d}$$

Substituting this value in (5)

$$n = 0.372\,p^2 - \frac{2.052\,p^3}{\pi d}$$

$$= 0.372\,p^2 - 0.654\,\frac{p^3}{d} \qquad (6)$$

The vertical ruling on the right-hand side of the diagram gives values of $n = pfy$ for varying diameters and pitches. This factor affords a rapid method for solving problems on the strength of a tooth, the value s being taken from the diagram (Fig. 1). Then,

$$w = spfy = s\,n$$

Explanation of the Chart

For the direct solution of a horsepower problem, only three variables are required—diameter, pitch and revolutions per minute. The result thus obtained is subject

*Engineer, American Clay Machinery Co.

to correction for width of face, a calculation that can usually be made mentally.

In addition to these functions the chart reads pitch velocity and number of teeth. Only a few of the "number of teeth" lines have been shown as it was found that they confused the diagram. The lines for 12, 15 and 20 teeth will afford a valuable guide in the selection of small pinions. Similarly the 100- and 200-tooth lines will suggest to the designer the use of a coarser pitch and fewer teeth. The oblique ruling for pitch velocity is numbered as a guide to the speed of the teeth.

A closed triangular loop must be formed, the bottom leg horizontal, the right-hand side vertical, the third side inclined at 45°. The bottom leg of the triangle is fixed by the diameter, the right-hand side by intersection of diameter and pitch, the left-hand side by intersection of diameter and speed.

EXAMPLE: What horsepower will a steel gear transmit, 21-in. diameter, 2-in. pitch, 8-in. face, 120 r.p.m.?

Lay a straight-edge horizontally on the "21-in. diameter" line, and mark with a pencil point its intersection at the left with 120 r.p.m., at the right with 2-in. pitch. Through these points draw a vertical line in the right-hand ruling, an oblique line in the left-hand ruling, and from their intersection follow the horsepower ruling out into the upper margin, where we read over 200, say 210 hp. The face is wider than 3 p; hence, there is no correction for face.

The detailed calculation of the above gear by Lewis' method is:

$$v = \pi \frac{dr}{12} = 0.26 \times 21 \times 120 = 654;$$

s = say 10,000 (from table);

$\frac{d}{p} = \frac{21}{2} = 10.5$, hence number of teeth = 33 (table);

and $y = 0.104$.

$$Hp. = \frac{10{,}000 \times 2 \times 8 \times 0.104 \times 654}{33{,}000} = 329$$

FIG. 1

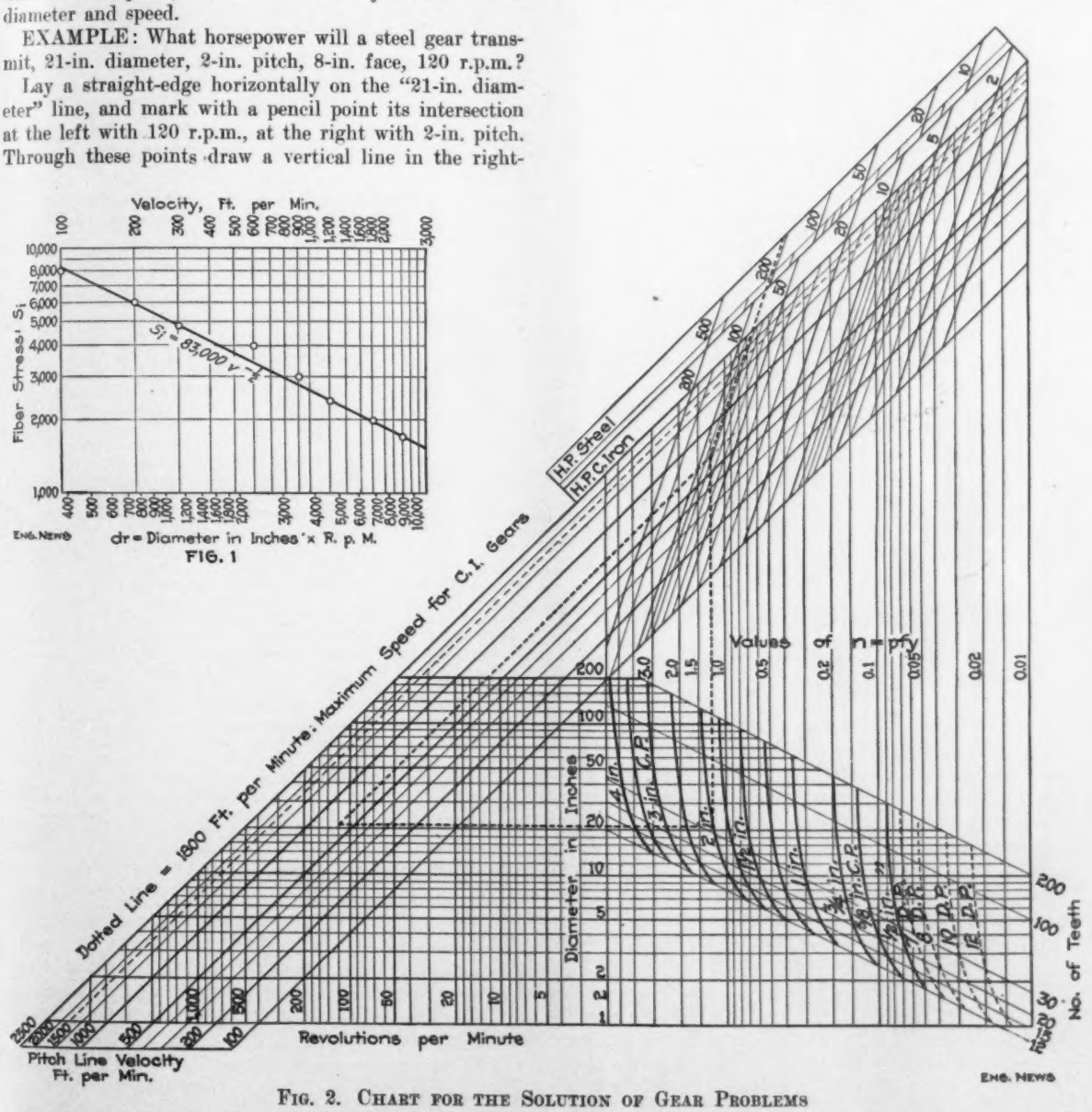
H.P. Steel
H.P.C. Iron
Dotted Line = 1800 Ft. Per Minute: Maximum Speed for C.I. Gears
Values of n = pfy
Diameter in Inches
Revolutions per Minute
Pitch Line Velocity Ft. per Min.
No. of Teeth
ENG. NEWS

FIG. 2. CHART FOR THE SOLUTION OF GEAR PROBLEMS

(Worked out for 15° involute or cycloidal systems, for the following values: Fiber stress for cast iron, Si = 83,000 v−½; for steel, Ss = 2.5 Si; horsepower, 0.000008 drspfy.)

Note—Chart applies directly to gears where face = 3 × pitch, or wider. For narrower faces multiply the horsepower by $\frac{f}{3p}$

This figure is higher than the chart reading, for two reasons: the higher value assumed for s in Mr. Lewis' table, and the wider face.

It will be found that for the same values of s and f as are used in the formula, the results will check.

Since writing the foregoing, the writer's attention has been called to the tests by Prof. G. H. Marx, of the breaking strength of gears, reported in the January, 1913, *Journal* of the American Society of Mechanical Engineers. These tests were made on 10 diametral pitch gears of 20, 30 and 40 teeth, and seem to indicate (1) that the fiber stresses recommended by Lewis are unnecessarily low, particularly at high speed; (2) that instead of decreasing uniformly with the pitch velocity, the strength of the teeth drops suddenly to a minimum at a critical velocity between 200 and 300 ft. per min., and at higher speeds, up to 600 ft. per min., the strength is nearly uniform or even increases slightly; (3) that the y factors do not properly represent the strength of the various tooth profiles; (4) that the number of teeth engaging simultaneously should be considered.

It does not seem practicable to apply these interesting results at the present time. Before they can be used freely and with confidence, the strength curve should be determined at higher velocities than 500 ft. per min. and on gears of different pitches, the new values of y should be tested on different tooth profiles, and a series of factors of safety developed for different classes of machinery and different materials.

The Lewis formula has given good results in the past twenty years of service. Gears proportioned by it do break occasionally, but not too often, and seem to wear well without being unduly heavy. For many classes of nicer work, for automobile and crane and motor gears, newer formulas must be developed from the newer data; but the writer feels that the wide acceptance of the Lewis formula is based on real merit, and will guarantee its use by designers for many years to come. To lighten their labors this diagram is offered.

✻

The Dust-Precipitating Plant of the Riverside Portland Cement Co., Crestmore, Cal.*

After two years of experimenting and with the expenditure of several thousand dollars, a dust-eliminating plant working on the Cottrell process† has been completed at the works of the Riverside Portland Cement Co., at Crestmore, Calif. It is claimed that this entirely eliminates the discharge of dust to the atmosphere, the chimney now showing only smoke from burning oil and minute quantities of volatilized potash, which condense on striking the cold outer air (and furnish free fertilizer). Each kiln has a separate double treater on the top of its stack, and any kiln and treater can be shut down without affecting the rest of the system, or the gases from one kiln can be passed through one half of the unit. Each half of the precipitating unit is rectangular, 14 ft. high, 12 ft. wide and 35 ft. long. In the precipitation box is a system of electrodes between which a uni-directional high-tension discharge (60,000 volts) passes. The dust-laden gas enters the precipitation box at a temperature of about 825° F. and a velocity of about 4000 ft. per min. Once each hour the collecting electrodes are mechanically cleaned of dust which falls into hoppers, is weighed on automatic scales and carried to bins, where it is shipped as filler for fertilizers or asphalt paving material.

Measurements have shown that each kiln stack delivers to its treating box about 5,000,000 cu.ft. of gas per hour, carrying about 700 lb. of dust. It is reported that the dust collected yields a revenue more than sufficient to pay for the operating cost of the treating plant, including energy, labor, depreciation and interest.

*From information furnished by the Western Precipitation Co., 1016 W. 9th St., Los Angeles, Calif.

†This process of electrical precipitation of suspended matter was described in "Engineering News," Oct. 26, 1911.

✻

Two Large Forced Draft Blower Sets, each driven by a 600-hp. Terry turbine, are to be installed at the power plant of the Rhode Island Co., at Providence, R. I. The turbine drives through a set of Falk reduction gears, a double-inlet Sorocco blower, manufactured by the American Blower Co. Each unit has a capacity of 250,000 cu.ft. per min., and supplies draft to Taylor stokers. The speed of the turbine is 3370 r.p.m. and of the blowers 460 r.p.m., the speed reduction being 7.35 : 1.

The Harlem River Crossing of the Lexington Ave. subway in New York City is being made by sinking successive sections of a steel framework inclosing the steel lining for the tunnel and covering the whole with concrete laid under water, after the method made familiar in the Detroit River tunnel of the Michigan Central Ry. ("Engineering News," Mar. 17, 1910, p. 318). The crossing made in this fashion is 1080 ft. long, connecting at either end to the regularly driven tunnel, which on either side of the river is cut-and-cover work.

The river section is divided into five parts, each comprising a complete steel frame and each sunk independently and connected to the adjacent length of tunnel already in place. The first section was sunk Aug. 29, the second, Sept. 26, and it is expected that the next three will be placed in regular order.

The section sunk on Sept. 26 is a steel frame 220 ft. long, 76 ft. wide and 24½ ft. high. It is essentially a box-like frame of structural members with the four single-track tunnel openings formed by properly curved lattice girders backed by steel plates. The framework, which is buoyed up during sinking by four large transverse air tanks, was floated into place immediately above the proper location on the river bottom, which had been dredged to grade, and in which pile bents had been placed to receive the frame. The framework was attached by lines to adjacent pile clusters. Water was then slowly let into the sections of the lining which had been bulkheaded off and the whole framework was gradually sunk until it was supported only by the buoyant air tanks on top. Water was then slowly admitted to these until the tanks were under water. The tanks were divided into compartments so that there was no rush of water from one end to the other, and they sank very uniformly. When they were under water, the whole mass was suspended from two derricks on a nearby float, and the framework was lowered to its final position, divers controlling the proper location. The divers also controlled the bolting of the frame to the adjacent section already placed, by a series of pilot pins, arranged to insure accurate alignment and grade.

Adjustment of the frame laterally was made by lines attached to the frame and to the adjacent pile clusters, through pulleys on which the lines passed to the derrick barge. The adjacent sections come together in a butt joint, which is reinforced by a flanged plate extending from one frame to the other. The concrete is deposited in a continuous sheet over this joint.

The sinking of the two sections has been successfully and rapidly done. Concrete is now being deposited under water around the steelwork by a specially constructed tremie system similar to the one used at Detroit.

The work is being done by the Arthur McMullen & Hoff Co., of which Mr. Olaf Hoff is consulting engineer. Mr. Hoff was connected also with the Detroit River tunnel work. The entire work is under direction of the Public Service Commission of the State of New York, First District, of which Alfred Craven is Chief Engineer, and Robert Ridgway, Engineer of Subway Construction.

EDITORIALS

The Passing of Edisonian Research

Every reader of engineering history knows of Thomas A. Edison's remarkable experiments which led up to the development of a carbon-filament electric lamp—experiments in the course of which is studied the incandescence of every available material which could be worked into filament form. Such research is notable for its cost, its slowness in producing results, and its often unintelligent though persistent industry. We have before this remarked on the inadequacy of this type of research in solving the technical problems of the present, no matter how necessary it was 30 years ago, or how great its fruits then when the fundamentals of electrical science had hardly been laid and the refinements of today were inconceivable. Naturally, under such primitive conditions of a science, the commercial utility of careful physical and chemical laboratory work along theoretical lines could not be appreciated as it is now.

A remarkable comparison of the old and new methods is given by the history of the "half-watt" or "nitrogen-filled" tungsten-filament incandescent electric lamp, described elsewhere in this issue. By the extensive use of tungsten lamps, the peculiar blackening of some bulbs has become a matter of common knowledge. It is this blackening that has prevented higher efficiency of light production. In endeavoring to remove this trouble, for a while all sorts of variations in making the filament and exhausting the globe were tried by the manufacturers. But this was a case, like many of the present problems, where the phenomena involved were so obscure and the reactions so minute in themselves, though great in accumulated results, that mere blind groping, in the hope of stumbling on a solution, was foredoomed to failure. In due time the problem was put up to the theorists of the research laboratory of the General Electric Co., and a logical attack was planned for chemists and physicists. They analyzed the minute amounts of gases in the bulb; they studied the deliberate fouling of the vacuum, and they measured the loss of filament weight. Once it was known, as a result of the first skirmish, that evaporation of the filament limited the attainment of higher temperatures and higher efficiency, the next step was obvious. Both theory and experiment pointed, in reducing the evaporation, to the use of an inert atmosphere, like nitrogen, in place of a vacuum. This proposal, however, brought with it the further problem of reducing the heat losses by convection. A better understanding of the phenomena and laws of convection had to be developed. (Some of the wider service of the results of this side line are seen from Langmuir's discussion of heat-loss phenomena, as reprinted in our issue of June 5, 1913.) Finally in approaching the maximum temperature at which the filament remained intact, the convection loss of energy (which increased with temperature far less rapidly than did the radiation) was made relatively insignificant; by a mechanical trick in construction, the convection loss was still more reduced and the half-watt lamp took on the shape in which it is now presented to us. The make-up of the device, moreover, is one which a wholly "practical" lamp maker would have prophesied impossible to secure. Where cut-and-try methods had made no advance, a scientific attack has made a brilliant success.

⁂

How the Belgian Iron Industry Maintains Itself under International Competition

The Iron and Steel Institute of Great Britain holds its fall meeting this year in Belgium. Among the notable papers for that meeting is one by Baron E. Laveleye, of Brussels, giving a historical review of the development of the Belgium iron industry.

Although Belgium is one of the smallest of European industrial nations, in the development of iron and steel metallurgy it stands in the forefront. It is of much interest, therefore, to read Baron Laveleye's statement of the methods by which the ironmasters of this little country have more than held their own against the competition of rivals far larger and stronger, backed by the political and financial influence of the most powerful nations of Europe. It is noteworthy that Baron Laveleye places first among the methods by which the Belgium ironmasters have been enabled to hold their own in the race of international competition, the fact that they have never allowed an improvement to be made in the industry without either adopting it or trying it. We quote as follows from his paper:

A comparison between the development of the Belgium production of steel with that of neighboring countries obtaining their fuel and ores from the same source, Germany and France, is interesting, and the figures quoted below tell their own story, particularly when it is borne in mind that only a portion of Belgium is concerned, and that it is an instance of a free-trade country fighting for its existence against its great protectionist neighbors:

	Belgium	Germany	France
	Production of Steel		
Years	Tons	Tons	Tons
1906	1,400,000	11,000,000	2,500,000
1911	2,100,000	15,000,000	3,700,000
Increase	710,000	4,000,000	1,200,000
Increase per cent.	50	37	48

This table shows that Belgium has well maintained her industrial position as regards the iron industry despite the efforts of her powerful competitors, and despite the "dumping" with which unprotected countries, or countries but imperfectly protected by customs duties, are always menaced.

It is particularly in the domain of industry that the well known Belgian motto of William the Silent, "Repos ailleurs," which means "No rest here," applies. There is "no rest" in business. Whoso pauses falls behind and finds himself outdistanced.

We have, as a matter of fact, to fight against competitors powerfully organized as well as most favorably situated, and highly protected by the fiscal barriers that one of the two (France) has just recently further raised.

Our small country has its work cut out to keep its place "in the sun," and it is only by never allowing an improvement to be made without either adopting or trying it, by relying upon the energetic and hardworking labor classes to whom free trade supplies cheaply the necessaries of life, and by constantly increasing the productive capacity of their

works, that our ironmasters have succeeded in maintaining the struggle on an equal footing and without allowing themselves to be outdistanced.

Some satisfaction is to be derived, likewise, from the fact that we have attained this result by our own efforts and without help, in spite of the fact that our products are sold at much cheaper rates than those of the competitors referred to above, or even those of the great Anglo-Saxon productive countries, Great Britain, and, particularly, the United States.

Numerous great iron works which are quoted as examples of prosperity, and to which our own are not to be compared in size, would find themselves in very different positions if they had to sell their product at the low rates with which Belgian manufacturers have to content themselves. It must be borne in mind that Belgium is compelled to accept as an average selling price the prices which rule in the international export market; as it is in this market, and at great distances, that our products find their sale. No other country exports so large a proportion of its produce as our own.

The United States exported, in 1904, on an average 7% of its product; France, 10%; and Germany, 33%; whereas Belgium only retained for her own use 20%, and therefore exported about 80% of its manufactured products. At the present time these proportions are about 4¾% for the United States; 13% for France; 30% for Germany, and 43¾% for Great Britain.

Certainly the courage and enterprise of the Belgium ironmasters deserve worldwide admiration. One inevitably contrasts the position our American iron industry so long held, demanding high tariff protection in the home market in addition to the natural protection against foreign competition afforded by the 3000 miles of Atlantic Ocean. But the courageous leaders of the Belgium iron industry have depended for nearly their whole market on what they could secure in the scramble of international competition, where they were pitted against competitors much larger and more powerful, backed in many cases by strong political influence.

The distinguished success of the Belgium ironmasters in the struggle is not to be explained on the cheap-labor theory which has so long been deemed a sufficient answer in this country to any references as to the achievements of foreign competitors. The wage scales of Germany, France and Great Britain are not greatly different from that prevalent in Belgium. The chief reason for the prosperity which has attended the Belgium iron industry, is, as Baron Laveleye says, to be found in the extent to which the leaders in that industry, under the stress of competition, have sought to adopt every new invention and improvement which promised to reduce production costs and improve quality.

That the reverse condition has obtained in this country, and that the absence of competition has permitted manufacturers to continue along in the old ruts rather than go to the trouble and expense of developing new improvements is also too well known to require demonstration.

Four Garbage-Disposal Contracts

Conditions in a number of cities where garbage disposal by reduction is practiced or where contracts for disposal by reduction have recently been let, illustrate anew the folly of the method which has long prevailed in dealing with such contracts.

At Chicago, as noted briefly elsewhere in this issue, the garbage-reduction works have been shut down and makeshift methods of disposal are being employed. This has come about through dilly dallying for two years with letting a new contract until it was too late to build a new plant before the old contract expired, then rushing through the city council an ordinance for buying the existing reduction works under an appraisal plan which broke down when it was put to the test, leaving the city, on Oct. 1, with neither a contract nor a plant of its own. As if this sort of thing had not gone on long enough, the estimable medical head of the health department of Chicago, to whom the city council shifted this engineering problem when it voted to buy the garbage-reduction works, is reported to be proposing to adopt a system of garbage treatment, which, it appears, has never yet been tried on a large scale, if at all.

At Philadelphia, the city has just suspended the garbage-collection-and-reduction contract and taken up the work itself, on account of alleged nonfulfilment of some of the terms of the contract. The contractor, it is reported, maintains that various embarassments, including an earlier taxpayers' suit to prevent payment under the contract, are a part of a plot in the interest of a rival contractor who failed to get a new contract at the last *annual letting* and whose plant has since been idle. (Comment on the folly of short-term garbage contracts, with particular reference to Philadelphia, was made in our issue of July 3, 1913.) It should be understood that the present city administration is not a party to whatever plot may exist. It should also be understood that the contractor for the year 1913 took the work at a price far below what the city had been paying to its rival and that it is now time to prepare for the 1914 contract.

What the outcome of the recent New York City garbage-reduction contract for a term of only three years, with option of extension by the city to five years, will be, remains to be seen. (Under this remarkable contract the city was to be paid for its garbage delivered at the water front; see ENG. NEWS, Aug. 7, 1913.) Up to a few days ago no actual construction work had been done under this contract, although the contractor must take the garbage of the city on Jan. 1, 1914, now less than three months hence. He may make temporary disposal until May 1, 1914, subject to approval by the local health department, but even seven months is not a long time to build a 2500-ton garbage-reduction plant. Moreover, "the farther 'tis from England the nearer 'tis to France"; or, in other words, any period of temporary disposal cuts down by that much the three years which the contractor has to get back his entire capital investment, in case the city does not extend the contract.

We shall stop with one more example of ill-considered garbage-disposal contracts. In our issue of Aug. 28 we published an account, with editorial comment, of a garbage-reduction contract just awarded by the city of Los Angeles, Calif. Here, too, the city was to be paid for the garbage, but instead of carefully drawn specifications for bidders, like those in the New York case, there were no specifications at all so far as the character of the reduction plant was concerned. Just what the status of the Los Angeles contract is at the present moment we cannot say, but some weeks after its award the contract had not been executed, owing, it is said, to changes suggested by some of the city officials—wholly in keeping with the vacillating action and the failure to act on garbage disposal at Los Angeles for a year or more past. With two different types of garbage furnaces consigned in succession to the scrap heap in Los Angeles it might be expected that the city would have learned a lesson before this and have secured and followed competent engineer-

ing advice in letting another contract. We understood that one of the (too many?) city officials having control of garbage disposal at Los Angeles distrusts "experts"—a feeling which seems to be even more prevalent among the city fathers on the Pacific Coast than in other parts of the country.

Whether it be "experts" or merely experienced engineers that are needed at Los Angeles and elsewhere, the time has certainly come when a change should be made in the unbusinesslike and wasteful methods and lack of all method which have so long prevailed in most of our cities when dealing with garbage disposal. Either longer contract terms or out-and-out municipal ownership should be adopted, and in either case the complicated technical problems involved should be entrusted to competent engineers.

The Interstate Commerce Commission's Revision of Express Rates

The recent revision of domestic express rates by the Interstate Commerce Commission, the Parcel Post scheme of charges, and the attempted rearrangement of railway freight rates according to geographical zones, taken together, show a consistent attempt to place the transportation facilities of the country more nearly on a "cost of service" basis; bringing such services as close as economically possible to the generally equitable plane that is more or less approximated in local telephone and telegraph services, or water, gas and electricity supplies.

Naturally the express companies have opposed the introduction of a new scheme of computing charges, particularly one which would cause at least 15% loss of revenue. Perhaps it is too much to hope for an absolutely unassailable revision of express rates which have, like Topsy, "just growed" with the years. The criticisms we have heard are of two sorts: one claiming that the great complexity and strangeness of the new system would require two years to put it into effect, the other contending that cost of service alone cannot be a fair basis of *any* transportation rates.

The first objection is not weighty. The principles behind either old or new system are few and simple, and the fundamental features of both are so simple, and the fundamental features of both are so similar that any employee whom the express companies would retain at all could seemingly use the new system as easily as the old.

The second criticism has but little more weight, though perhaps the fact is not so quickly evident. There are many elements, necessarily persisting in any national schedule of transportation rates, which have custom and local expediency as their only logical basis but the shorter the haul and the smaller and more numerous the articles carried, the less departure can these disturbing elements effect from the cost-of-service basis. Matters of great economic significance in heavy transcontinental freight carriage fail to appear in the express and parcel-post services. For instance, in the transportation of large or heavy cargos from near the Atlantic to near the Pacific, the prevailing water-carriage rates from coast to coast have to be considered; the price of rail carriage, largely irrespective of service cost, can not be much more than the water rates plus the charges to the Atlantic seaboard and those from the Pacific inland to destination. With the comparatively light express shipments and the still smaller mail parcels, the time required over such an alternative route, in itself, eliminates this competition. Formerly, there was considerable concession in railway-freight rates for import and export shipments, but these allurements have gradually diminished from natural causes—notably the decrease of incentive for securing the traffic. Foreign express matter has been slightly favored but only for large shipments (in excess of 300 lb.) and it is questionable if the trade is attractive enough to have longer maintained any concession. Therefore, the argument that it is idle to attempt to secure a cost-of-service basis for any class of transportation, has far less weight in the express than in the railroad business.

The system proposed by the Interstate Commerce Commission is not fundamentally new unless we so term any attempt to remove accumulated complications and avenues for discrimination.

Under the practice of the companies there were two main classes of express matter: (1) "merchandise" and (2) "general-special," the latter including a long list of articles of comparatively grosser character and lesser value—largely food and agricultural products, but yet all things which public policy urged should be moved rapidly even though their lower value prevented the imposition of rates which may be laid on finer articles. The old "merchandise" charges were proportioned per pound according to a tariff for 100-lb. shipments, all lesser weights taking higher graduated charges when the hundred-weight tariff was less than $2 and, if this was over $2, such graduated charges only for weights under 50 lb. In finding any actual charge to a customer, the express agent first had to find from his tariff books the 100-lb. rate and then to turn to his graduation tables for the higher actual charge corresponding to the weight and base rate.

"General-Specials" have been billed by the pound at 100-lb. rates (from 60 to 80% of merchandise rate) with a 35c. minimum (25c. minimum for each company in case of more than one carrier). Charges on a number of packages forming part of a single shipment have been aggregated where the average weight was above 20 lb. Valuation charges for declarations in excess of $50 (or 50c. per lb. on over 100 lb.) have ranged from 10 to 20c. per $100, according to the rate for carriage.

On this comparatively simple basis all sorts of special schemes have been hitched, resulting in opportunity for a wide range of discrimination and favor to the frequent shipper who understood the game and which, for identical service, were denied to the occasional customer unaware of the existing loophole.* In many smaller communities, where more neighborly relations can prevail between the express-company employees and the people generally, such discrimination has been small because of efforts to favor as many townspeople as possible.

*These were the notorious "Sections A, D and E" and the "Scales J, K, L, M, N, O and Z." The three sections named were created to meet postal competition, when necessary, and are best studied in reverse order. E was confided to manufacturers and large shippers; any merchandise package marked "Value not exceeding $10," unsealed and prepaid, went to any express office in the country for 16c. per lb. (compared with 25c. to 40c. for the ordinary quoted rate). D was confided to the larger advertisers and was intended for printed matter; these packages, if marked with a designation of contents and "value not exceeding $10" and prepaid, were carried at ½c. per oz. with a 2c. discount on packages of 50 oz. or more. Finally under Section A the same matter was carried at straight merchandise pound rates (which, where a package weighed over 4½ lb., were lower than Section D rates for any tariff under $8 per 100 lb.) pro-

The graduation tables evidently have been built up to milk the small-shipment business (the rates for 10 lb. running up to three or four times the pound charge on a hundredweight) compared with some 1½ times in England. There have been also numerous cases violating the idea that a sum of short-haul charges should not be less than a long haul plus transfer costs. These cases have arisen through lack of unity in the express business of the country and different practices in graduating charges on shipments under 100 lb. where more than one carrier has been involved. A peculiar juggling of the graduated charges has led to further burdens. For packages up to 7 lb. weight, the 100-lb. tariff for the whole distance was found and the graduation applied as a whole whether one carrier or more entered. But on larger shipments, unless there were two companies in the place of destination, the base tariffs of each carrier were graduated separately before addition—which raised the resultant charge, the effect of each additional graduation being about ¼c. per lb. (In recent weeks, the companies voluntarily have largely given up multiple graduations.) The gross effect of such a small unit burden may be seen by noting that 95% of express shipments have an average weight of 25 lb., which is above the single-graduation limit and below the pound-rate.

The most powerful influence on express rates perhaps has been that exerted by the contracts between express companies and the railroads by which the latter secure from 40 to 60% of the gross receipts, with the express rates usually stipulated not to fall below 1½ times the first-class freight rates.

The order of the Commission removes all the complicated exceptions to the old classification, reducing it to the simple scheme of merchandise ("Class One"), articles of food and drink ("Class Two") and very small packages ("Class Three"). A few broad exceptions have been made to permit the movement of second-class articles in large quantities. The actual classification list of articles has been improved by giving each in its proper place alphabetically instead of under some group word like "musical instruments," etc.

Aggregation of charges on multiple-package shipments is ordered above an average weight of 10 lb. per package. Charge for additional declared value of a shipment is made 10c. per $100 added value above $50 (or 50c. per lb.)*

The greatest change seen lies in the system of computing rates. A scheme has been drawn up as though one express company controlled the national service and in that way all occasion for multiple graduations is eliminated. The country has been divided into blocks (bounded by parallels and meridians) and rates (applying to all offices therein) have been computed for carriage between each block and every other block where interstate commerce can occur. But these, through duplication and approximation, reduce to 294 base rates which give 294 graduation tables for weights of 1 to 100 lb. All the symbols for rates from one block to any of the 830 other blocks can be printed on a single sheet (easily readable in 8x10-in. size) and the whole set of graduation tables for the 294 possible key numbers need occupy only 17 pages (8x10-in.). To be sure, a book of all rates out of all the blocks in the country must make a large volume (8x10x1½ in.), but few shippers need concern themselves beyond the sheets for their own immediate territory.

Naturally, some further refinement is necessary to give fair rates between offices in the same or in adjacent blocks. This has been secured by dividing each block into 16 squares and computing rates from each square to all squares in its own and adjacent blocks. This might seem to introduce great complication but the Commission has put all such tariffs that cover interstate trade into 172 printed pages (8x10 in.) and for a given office a half page gives all the possible sub-blocks. Of course, it would be desirable to have the rates for intrastate traffic readjusted in harmony with the interstate rates themselves and this might increase the tables needed by any one agent but by only a page or two.

The Interstate Commerce Commission reports that the rates have been computed to cover the costs of collection, transportation and delivery, according to average figures for the section of the country considered and taking into account the fair value of railway property needed in transportation between the points studied. The idea has been discarded that existing percentage contracts with the railroads should be allowed to influence rates.

Many of the most experienced operating officers of the express companies have advocated, within their concerns, such a simplification as the Interstate Commerce Commission now proposes. Natural local differences, and surviving peculiarities of older concerns have prevented (in spite of a strong community of interest) a completely successful coöperation in seeking such an end, although some progress had been made. It evidently required the intervening hand of a third party, and one with authority, to over-ride ideas which one party or the other could not give up.

It is to be hoped that the express companies will not contest the Commission's recent order as a whole and that opportunity will be accepted for the proposed two-year test of the cost-of-service basis. This will mean that the railway contracts should be superseded by new ones fairer to the express companies under the new rates. The express carriers will need to arrange their strictly local rates in harmony with the interstate charges. To make the test of greatest service, the railroads and the express companies will have to coöperate with the commission and resign themselves to the acceptance of a modest reward in proportion to the cost and value of the service rendered.

A survey of the express service of the country shows that it is very largely in the hands of a small but distinct group of men whose business affiliations are closely interwoven; yet the several companies preserve all the formalities of independent carriers in routing shipments

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vided marked also "For Free Distribution." Scale J made a carload rate for horses amounting to about half the railroad freight rate on the same shipment; Scale K gave a rate of 60 to 80% merchandise rates on beer and temperance beverages, with a 30c. minimum; L gave package rates on crated berries varying from 5c. to $12, depending on size of crate and length of haul (the 100-lb. rate on berries was ordinarily 60 to 80% the corresponding merchandise rate); M similarly gave a case rate for eggs of 14c. to $3.30; N covered the "general-special" shipments above noted; O gave live poultry in crates a rate of 74 to 80% merchandise rates; Z gave cheese 60 to 80% merchandise rates, with a 25c. minimum.

*Except on paintings and statuary worth over $550 (when the rate varies from 25c. to 50c. per $100 added value in excess of $50 or 50c. per lb., according as the first-class rate varies from $1 to $8), and on live animals (which are individually specified).

LETTERS TO THE EDITOR

Combined Wood and Stone Pavements in England

Sir—The article on "Oak-Keyed Belgian Blocks," in your issue of Sept. 25, reminds me to inform you that almost the same kind of pavement was laid in Norfolk and Union Sts., Sheffield, England, about twelve years ago and was still in use four years ago. The inventor was Colonel Bingham, an alderman of Sheffield. Further particulars could doubtless be secured from the city engineer and surveyor of Sheffield [C. F. Wike].

It does not seem as though Mr. Alcott's patent on the pavement described in your issue of Sept. 25 would hold in Great Britain or her colonies.

R. LACY.

120 Chestnut St., Rutherford, N. J.,
Sept. 26, 1913.

[In our issue of July 25, 1901, we published the following note regarding combined wood and stone pavement in still another British city, as follows:

A Combined Granite and Wood Pavement was laid as an experiment at Leicester, England, a few years ago. It consisted of alternate rows, at right angles to the length of the street, of granite blocks 3 in. in width and Australian hard-wood blocks 1 in. wide and 9 in. long, the fibers being vertical. In other words, 3 in. of stone alternate with 1 in. of wood. The object of this combination was to secure the durability of granite without its attendant noise. It is said that very satisfactory results attended its use. The pavement was laid at street intersections, and, on repaving the streets with wood the combination pavement has given place to wood alone. The character of the joints and the relative wear of the wood and the stone is not stated in the London "Contract Journal," from which the foregoing is taken. E. G. Mawbey is Borough Surveyor of Leicester.

It will be noted that there is considerable difference between the alternate rows of wood and stone at Leicester and the oak-keyed belgian blocks (old blocks) laid by Mr. Alcott. It would be interesting to know just what the combination was at Sheffield, and if the wood was not wedged between the stone how the joints were filled; also how much of the pavement was laid, how it has worn and any other useful facts regarding that or similar pavement in Sheffield or elsewhere.—ED.]

Earth Pressure against Foundation Walls

Sir—On Sept. 1, a wall of a new high-school building being erected at Manhattan, Kan., was overturned by the earth pressure behind it. Several men were working near the foot of the wall when the collapse occurred, but, fortunately, the latter was seen to crack and start in time for them to escape without injury.

The wall which failed is an example of the carelessness often seen in the design of building foundation and area walls to resist earth pressure. It was to form the side of an underground coal bin which was to extend to grade only, a height of 16 ft. Here it was to be covered with a reinforced-concrete roof through which the coal was to be dumped. The wall in question was of limestone rubble, laid in portland-cement mortar; it was 58 ft. long, had no buttresses, pilasters or brace walls and was only 18 in. thick. The plans called for a 13-in. brick cross-wall about one-third of the distance from one end but this had not been built when the accident occurred.

The excavation was in loose, sandy soil, as can be seen in the accompanying figure reproduced from a photograph taken about 24 hours after the accident. Back filling was carried on as the wall was built and was flushed with water. The last 5 ft. of backfill was completed but a short time before the collapse and this part of the fill had not been flushed. The crack started in the middle of the wall, near the top, as was to be expected.

RESULT OF FAILURE OF AN 18-IN. RUBBLE WALL AT MANHATTAN, KANSAS

Eye witnesses of the failure reported that about three minutes elapsed between the time the first crack started and the wall actually fell.

In rebuilding the wall, its thickness is being increased to 24 in. and three buttresses about 3 ft. wide and 5 ft. long at the bottom, tapering to 1 ft. at the top, are being built with it. For the additional masonry over that called for in the original plans, the contractor is to receive $350; otherwise he is to stand the full damages.

If the backfilling behind the original wall had been delayed until the roof and brick cross-wall were in place, it is possible that the accident would not have occurred during the construction of the building; but the wall would always have been unsafe. It is to be hoped that the time will come when due consideration will be given

to the earth pressure against building foundation walls, and these will be designed for what they are in fact—retaining walls.

R. A. SEATON.

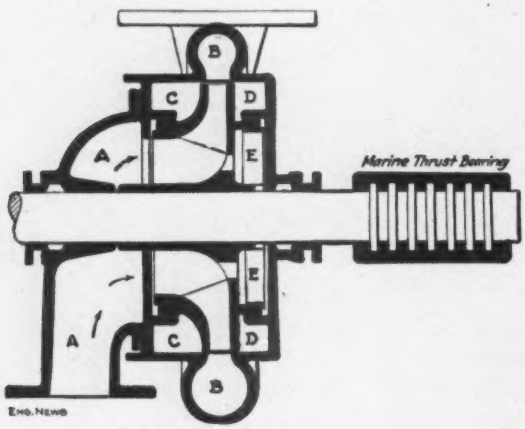
Professor of Applied Mechanics and Hydraulics, Kansas State Agricultural College, Manhattan, Kan.,

Sept. 19, 1913.

Balancing Devices for Centrifugal Pumps

Sir—I read with special interest the very interesting article on balancing devices for centrifugal pumps in your issue of Sept. 11, as less than a week before a trouble job, caused by defective balance, had fallen to my lot.

The pump in question was a 4-in. single-suction centrifugal. It received its supply, a thick liquid at about 160° F., under a pressure head of 20 ft. Its normal capacity was 300 gal. per min. against a head of 60 ft. The capacity was controlled by varying the motor speed.



Two identical outfits had been installed three years before. They operate some two months out of the year and it is imperative that one be in perfect condition during this period. One outfit has been entirely satisfactory since the start. The other has never run over a day without burning out bearings. Twice previously men from the factory had relined the outfit, rebabbitted the bearings, checked the position of the impeller and the holes in the impeller for balancing, but could not eliminate the trouble.

The season was on again and the bearings heated as soon as the outfit was started. The local men worked for two weeks trying to make it good enough to carry the load for short periods but with no success. When I took up the job it looked pretty discouraging.

The inclosed sketch shows the design diagrammatically, and is needed for discussion of the trouble.

The thrust was toward the left so it was evident that the balancing chamber *E* was free and helping. This, however, did not help to solve the difficulty, as the normal thrust was greatly overbalanced. To know just what was going on inside of the pump we took gage readings on the discharge, on the suction, at the point marked *C*, and at the point marked *D*. The pressure-head readings were as follows: chamber *A*, 20 ft.; chamber *B*, 60 ft.; chamber *C*, 26 ft.; chamber *D*, 58 ft.; chamber *E*, 18 ft.

Assuming that chambers *A* and *E* are 8 in. in diameter with a 1.5-in. shaft, a thrust of some 40 lb. would be created toward the right. The pressure difference between chambers *C* and *D*, 32 ft., with an outside area of 16 in. amounts to over 1500 lb., which thrust was to the left and was what burned out the bearings.

To remedy the trouble we simply bypassed from the discharge *B* to *C* and from *D* to the suction *A*. Gages were then applied to the pipes and pressures balanced by means of valves placed in the pipe lines.

The trouble was solved or, better, eliminated. For the first few days the operating department were afraid to let the pump run for more than an hour or two; they had come to look on it as a trouble maker. These shorter runs inspired a little confidence and it is now carrying the load.

The original cause of the trouble has not been located. It may be due to the impeller being cut on a taper, leaving a larger clearance on the *D* side than on the *C* side. A second cause might be in the wearing rings allowing different leakages on the respective sides. Of course, this would have to be determined in order to get maximum efficiency. However, this was a case where the apparatus was in place and had to run; reliability was the main item. With the present bypassing we know that thrust is a matter of the past.

H. C. W.

Philadelphia, Penn., Sept. 24, 1913.

NOTES AND QUERIES

Information is wanted on methods of specifying the proportions of mix for concrete definitely. Requiring 1:2:4 proportions of cement, sand and stone, parts measured by loose volume, is definite so long as the sand and stone are separate. If a graded gravel is found and is used for the aggregate, what volume proportions should be used to give an equivalent of 1:2:4?

The inquirer remarks that the graded gravel actually used may not be the same in effect as a mixture of the two parts of sand with four of the theoretical uniform gravel. In practice, is it customary in such a case to procure small lots of uniform sand and gravel and mix them to determine the volume of graded aggregate to be used? We refer the questions to our readers.

An Investigation of the Strength of Cinder Concrete

BY GEO. E. STREHAN* AND HAROLD PERRINE†

The availability and economy of anthracite-coal cinders or clinkers as an aggregate in certain forms of concrete construction, together with the excellent fire-resisting qualities of cinder concrete, has caused their wide and constantly increasing use. This popularity and a lack of available basic data led to undertaking a thorough investigation of the chemical, physical and elastic properties of cinder concrete as made and used in New York City.

The investigation, instituted during the past year and

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†Civil Engineer, Dept. Civil Engineering, Columbia University.

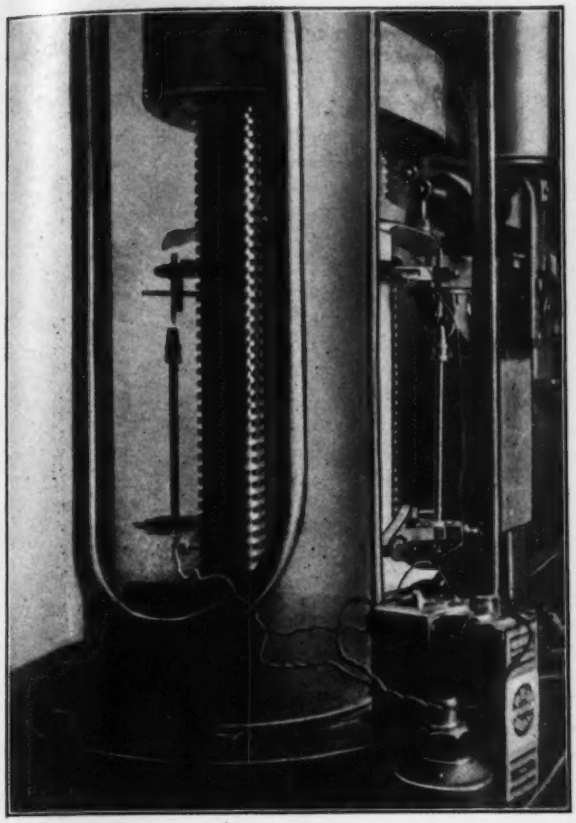


FIG. 1. COMPRESSION TEST, SHOWING EXTENSOMETERS

now in progress, is based upon the following general scheme:

1. Determination of the compressive strength with the elastic and other properties of cinder concrete, cast under working conditions as obtain in actual practice.
2. A study of the behavior of typical cinder concrete slabs under load, as affected by the character and percentage of reinforcement, thickness, span length, age and local conditions, with the view of aiding in theoretical design or establishing a standard loading test.
3. An attempt, through further tests, to recommend specifications tending toward an improvement in the product; i.e., greater density, greater uniformity, etc.

The physical and elastic tests are being conducted upon standard cylinders, 16 in. high and 8 in. in diameter, as recommended by the joint committee of the American Society of Civil Engineers and the American

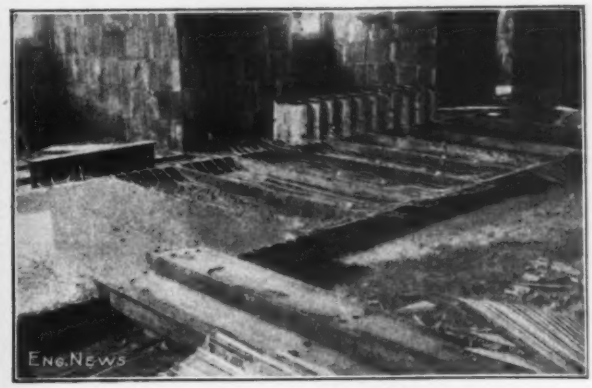


FIG. 2. TEST CYLINDERS AND SLABS, DORMITORY BUILDING, COLUMBIA

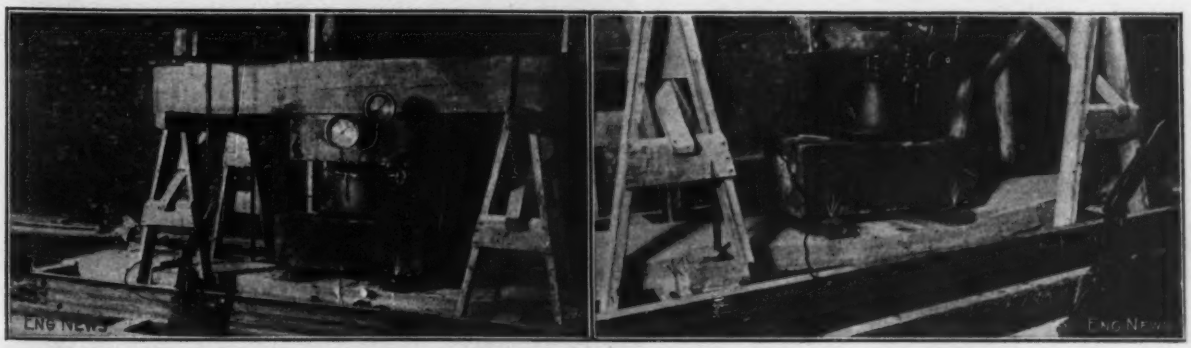
Society for Testing Materials. Galvanized-iron forms of these dimensions were taken to buildings in the course of construction in various parts of the city, and 40 cylinders cast at each location. All specimens were made under the personal supervision of a Building Bureau official.

The mixture used in the cylinders was identical with that going into the building at the time of arrival, no advance notification having been sent the contractor of the intention of taking samples. The various methods of handling, tamping, etc., were carefully noted.

Testpieces were taken from five buildings selected from three arbitrarily chosen zones, A, B and C, the intention being to find local variations, if such exist. Samples of the component materials were selected from the cement, sand and cinders in each case and physical tests and analyses run upon them. Through the courtesy of the Department of Chemistry, Columbia University, chemical analyses of the cinders will be available at an early date.

The cylinders were allowed to remain for several days under the atmospheric conditions obtaining on the basement floors of the buildings in which they were cast, at which time they were removed to the Columbia laboratory and kept in air at ordinary room temperature until tested.

From each of the sets of 40 cylinders, 10 were to be tested, respectively, at 1 month, 2 months, 6 months and 1 year. Results of tests up to and including 6 months have been obtained. They are tabulated on p. 724.



READY FOR TEST AFTER FAILURE

FIGS. 3 AND 4. TESTING CONTINUOUS SLAB; THIRD-POINT LOADING

WEIGHT AND COMPRESSIVE STRENGTH OF CINDER CONCRETE AS USED IN FIREPROOF FLOORS, NEW YORK CITY.

(The table covers 120 samples. Each figure given is the average of ten samples.)

Zone	A	B	B2	C
Mix	1:2:5	1:1:5	1:2:5	1:2:5
Weight, lbs. per cu.ft.	107	100	107	109
One month test:				
Crushing strength, lb. per sq.in.	407	507	818	980
Mod. of Elast., lb. per sq.in.	924,600	857,400	1,230,000	1,492,000
Two-month Test:				
Crushing strength, lb. per sq.in.	701	662	1,254	1,035
Mod. of Elast., lb. per sq.in.	1,134,000	1,030,000	1,740,000	1,428,250
Six-month Test:				
Crushing strength, lb. per sq.in.	933	754	1,744	1,478
Mod. of Elast., lb., per sq.in.	971,000	1,050,000	1,348,000	1,276,000

Note: B was hand-mixed; A, B2, and C were machine-mixed. The modulus of elasticity was determined at a point of the elastic curve corresponding to one-fourth the ultimate strength.

The remainder of the investigation is now in progress. The photographs herewith illustrate some of the work.

The tests are being conducted in coöperation with the Bureau of Buildings, Borough of Manhattan, by the Department of Civil Enginering, Columbia University, and were made possible through the action of Prof. William H. Burr, who made available the William Richmond Peters, Jr., Fund for Engineering Research. The Bureau was represented by George E. Strehan, Assistant Engineer, and K. M. Boorman, Engineering Inspector. The actual tests were run, to date, under the direction of Harold Perrine by F. Miller and J. P. Maloy, Assistants in the Department of Civil Engineering, Columbia University, and by E. Kirchgraber and G. Lommel, senior students in civil engineering at Columbia.

The Half-Watt Tungsten-Filament Electric Lamp*

Formal announcement has previously been noted of an incandescent electric lamp with tungsten-wire filament developing a candlepower on a power consumption of half a watt. Further facts about the development of this type are now available.

In the operation of ordinary tungsten lamps it was found that they could be run as low in consumption as 0.20 watt per candle for a few seconds. The melting point of the filaments prevented any further increase beyond that figure. But even at 0.5 watt per candle the bulb blackened badly within a couple of hours. This blackening of the bulb was the chief cause which prevented running tungsten lamps at very high efficiency. There were indications that the life at these higher frequencies might be improved if a perfect vacuum could be obtained. Direct experiments in increasing the life by improving the vacuum were not very successful though it was admitted that there might have been no actual improvement in vacuum, since there were no reliable methods of measuring such very low pressures. An investigation was started to find out exactly what caused the blackening, and this resulted in the determination that, of all the gases that might exist inside the bulb, only water vapor ever produced blackening. It was found that the vapor attacked the filaments producing a volatile oxide of tungsten and atomic hydrogen. The oxide that collected on the bulb was reduced by the hydrogen, forming a black layer of metallic tungsten. The hydrogen recombined as low as 0.0001 mm. were found to produce very rapid with oxygen to form water which again attacked the tungsten, completing the cycle. Pressures of water vapor blackening and it was finally proven that a certain amount of blackening occurs at very high filament temperatures even in the absence of water vapor, due probably to ordinary evaporation.

Very many experiments were made to determine the loss of weight of the tungsten filaments when run at various temperatures and degrees of vacuum. These showed that the slow blackening of ordinary well made tungsten lamp globes, as well as those run at higher efficiency, was due to simple evaporation. The rapid blackening of poor lamps is still considered due to the presence of water vapor.

After it was definitely known where the trouble lay, the problem of improvement assumed more definite form. The rate of evaporation would have to be decreased to increase the efficiency of operation, or else the evaporated material would have to be prevented from blackening the bulb at useful areas. Two simple ways of attacking the problem were seen: (1) the introduction of gases, such as nitrogen or mercury vapor at atmospheric pressures into the bulb, and (2) changing the location of the deposit by control of convection currents. Each of these methods has been tried with success.

The trouble with the first method is that the use of gas causes loss of heat from the filament by convection. It was found that the heat loss by convection from small wires at high temperatures is very nearly as great as that from wires several times as large in diameter, and it is of great importance to use filaments of large diameter. Practically the same effect can be secured by winding the filaments in the form of a tightly coiled helix. Moreover, the convection loss in a given case goes up according to the 3/2 power of the temperature, whereas the radiation increases with the 4.7th power. Thus the convection loss becomes relatively less important at the limiting temperatures.

With helically wound filaments in nitrogen very high efficiencies can be obtained for a life of over 1000 hours per lamp. The blackening of the bulb is avoided and in properly designed bulbs the reduced amount of tungsten that evaporates produces only a slight brownish deposit in the upper part of the bulb. The following types have been made and tested, among others: (1) large units (upward of 1500 cp.) of very high efficiency, to be run at low voltage giving 0.4 to 0.5 watt per candle; (2) smaller units of low voltage varying in efficiency from 0.6 to 1 or 1.25 watts per candle, and adapted to street lighting on 6.6-amp. circuits, also for stereopticon lamps, automobile headlights, etc.; (3) lamps of several thousand candlepower to run on 110 volts with efficiencies of 0.5 watt per candle or better.

The temperature of the filament being several hundred degrees higher than in the ordinary tungsten lamp, the nitrogen-filled type gives a whiter light. It is possible to make these lamps so that their volt-ampere candlepower characteristics are practically constant during their life, and the ultimate failure is due to breakage of the filament with the candlepower still well above 80% of the initial value.

*From a description of the "Nitrogen Filled Lamp," by Irving Langmuir, in the "General Electric Review," October, 1913.

A Miner Entombed in the Continental Mine of the Lehigh Valley Coal Co., at Centralia, Penn., by a fall of rock on Sept. 26, was rescued Oct. 6. The rescuers were compelled to cut through 52 ft. of coal in order to reach the man, who was kept alive in the interim by means of food forced through a pipe which had been inserted in a 2-in. bore.

Preliminary Report of Army Engineers on the Central States Floods

At the time of the great floods in Ohio, Indiana and Illinois last March* there was a general cry for Federal help to the devastated cities and villages. Some blamed the Government's not having taken the minor streams under its control and prevented the floods, while others realized that the responsibility was local; but all, in view of the disastrous results of the tremendous rainfall, admitted that the problem was to big for local resources of knowledge, and called for a board of River & Harbor engineers to study the situation and advise. President Wilson had such a board organized.† The first report of this board—a preliminary report—was rendered a few days ago.

The board visited all the worst-flooded places in the three states named, and gave the prompt help of immediate counsel so far as this could be given; but the board found that

in general, immediate decisions were desired on matters the factors of which were so complicated that results could be expected only after thorough concentrated study, and that due to lack of data and time such decisions at this time are impossible.

Central Control Recommended

The board, by way of justifying its investigation, says that navigation interests were injured very extensively by the floods, and that interstate commerce was interfered with (by railway destruction, etc.). To protect interstate commerce, it says,

the first requisite for the prevention of interference with interstate commerce should be the exercise by some central body of supreme control of bridges and their approaches. This control should extend to city and county bridges.

Worse floods are not impossible in the affected region, says the board; equally heavy rainfall may have occurred in the past, but with less damage because channels were not so obstructed.

Building lines have been pushed forward into the streams, bridge abutments have been carried out beyond proper limits, piers so placed as to further choke the channels, and deck bridges with insufficient vertical clearance have been used instead of through bridges at proper elevations. On the flood plains cities and towns have been so located as to act as dams, and railroad embankments have been carried from bluff to bluc.

Reservoirs of No Use

The board does not recommend reservoir flood-control in Ohio; it discusses the possibilities briefly, and does not find them promising. Its general attitude, cautiously expressed, is this:

The board is at present not prepared to recommend means of preventing the occurrence of high stages in the rivers due to excessive rainfall.

Channel Improvment Looks Promising

On the other hand, the effects of floods may be minimized or "almost entirely prevented," by removing obstructions from the river channels and flood plains, by enlarging the channels, by leveeing, and by digging diversion channels.

The planning in this direction done at Columbus‡ is referred to, as illustrating the thoroughgoing possibilities of such channel control and correction. But, the board says, such work may protect the one locality but make matters worse for the lands downstream of that locality. The board concludes that the *problem is a general one for an entire river valley*, instead of a local one.

Comprehensive Surveys and Study Needed

Local studies for flood prevention and local surveys and gagings have been or are being made at several points; but,

so far as the board knows no comprehensive survey is being made that includes all the information necessary for solving the problem of flood control of any stream in the Ohio River basin.

Several suggestions are made to meet this well known unfortunate condition. All future surveys by Army Engineers for navigability should include data concerning *regulation and uses of the stream;* the whole subject of floods and their prevention should be fully investigated; the work of collecting information and formulating a plan of procedure with estimates of cost should be entrusted to the Pittsburgh office of the Engineer Corps; and, above all, the Federal government should claim and exercise authority over all the rivers in the region.

The last is so vital a matter that we quote the exact language used by the board:

The board has been much impressed in its examination by the evils of divided control of the water courses. The obstructions which have been placed along the various streams ought never to have been put there, and their construction should have been prevented, but since the control of rivers is in the twilight zone between the spheres of Federal and state authority, it developed that what was anybody's business was nobody's business, and no effective authority has been exercised by anybody. These rivers are feeders of a navigable stream and have an important effect upon the regimen of the Ohio River, and it is the opinion of the board that the authority of the United States should be exercised to prevent encroachments upon them exactly as in the case of navigable streams. It is believed that this is the only method of control which promises good results in practice. The board further urges that immediate steps be taken to exercise such authority, since bridges and other structures are to be rebuilt at once, and there is evident danger in several places that they may be rebuilt in an obstructive manner.

The Chief of Engineers on Federal Control

In transmitting the preliminary report to the Secretary of War, the Chief of Engineers* attaches a memorandum, which among other things discusses the problem of Federal exercise of authority over rivers much more fully than does the board's report.

PRESENT CONTROL—At present the Federal laws assert jurisdiction over bridges practically only over navigable waters. In rare cases this authority can be extended to include such structures over non-navigable feeders provided it is shown that the particular bridge affects indirectly navigable waters farther downstream. Any further extension of the War Department's authority in regard to bridges over non-navigable tributaries will require additional legislation by Congress.

The Federal government actually exercises a measure of authority in the matter of encroachments upon the upper and non-navigable parts of rivers by the dumpage of ashes, dirt, etc., as such materials are liable to be carried down the stream and deposited in the navigable portions of the river to their injury.

STATE COÖPERATION—The memorandum discusses how the Federal government could coöperate with State governments in river work in such a way as to avoid the evils of divided control over watercourses. Legislation by Congress and by the different state legislatures would be

*"Engineering News," Mar. 27, 1913, et seq.

†The board consists of: Lieut.-Cols. Francis R. Shunk and Henry Jervey, and Majors Charles S. Bromwell, John C. Oakes, Frederick W. Altstaetter, and Lewis H. Rand.

‡See report of Alvord & Burdick, "Engineering News," Sept. 25, 1913, pp. 631-633.

*Gen. Wm. T. Rossell.

necessary for this, and because various states would be involved there would be much risk of confusion and conflict. Nor would the coöperative control be efficient, as the existing Federal force could easily handle the work in addition to its control of navigable streams, with very small increase of personnel.

DEPARTMENTAL COÖPERATION—The Chief of Engineers also discusses whether coöperation with other departments of the Federal government is advisable, and *he recommends against it*:

> Any method of handling the flood situation that requires any increase of coöperation, mixed commissions, or other forms of divided control will be productive of results which will not be the most economical and will be less satisfactory than the people have a right to expect.

RESERVOIRS—On the subject of reservoirs the Chief of Engineers is not sanguine. He says:

> It is the present opinion of this office that very little expenditure of money on reservoirs in the Ohio Valley will be found to be justified in the interest of flood prevention alone. On the other hand, it is believed that, as recommended by the board, further investigation should be made at least of the more favorable sites if for no other reason than to make sure that all plans which have been advanced have received thorough consideration.

The collection of data, finding what gaps there are, recommending further measurements and surveys, etc., is now going on in the Pittsburgh district office of the Engineer Corps.

The American Road Congress at Detroit

The third annual American Road Congress was held last week in Detroit, Mich., being conducted jointly by the American Highway Association, the American Automobile Association, and the Michigan State Good Roads Association. A large number of State and local good-roads organizations also participated.

The Congress was a far more important gathering than that held a year ago at Atlantic City. The number registered in attendance was between 2000 and 3000, and while a large portion of these were from Michigan or were connected with the various road-material supply firms having exhibits at the Congress, there was also a gratifyingly large attendance of the members of state highway commissions and of the engineers in charge of state highway work, as well as many engineers interested in street construction.

Sessions of the Congress were held every day of the week from Monday to Saturday, and were very well attended, especially in view of the fact that the auditorium in which the sessions were held had such acoustic defects that a large part of the proceedings were unheard by the audience. Monday's sessions were given up to various general addresses, the most notable of which was that by Secretary of Agriculture Houston, in which he discussed the Federal government's relation to road improvement, taking a conservative view of the subject. Among the other speakers was Hon. A. W. Campbell, Deputy Minister of Railways and Canals of Canada. A reception and dinner in honor of Secretary Houston and other distinguished guests was held in the evening.

The morning session on Tuesday was devoted to national legislation and was made especially notable by the address delivered by Congressman Shackleford, of Missouri, who is Chairman of the House Committee on Public Roads. Not only as a member of Congress, but as chairman of this important committee, Congressman Shackleford holds a commanding position with reference to Federal road legislation.

The prevailing sentiment of the Road Congress is doubtless strongly in favor of Federal aid, although there is great diversity of opinion as to the way in which such aid should be given. In general, however, the automobile interests and a large proportion of the good-roads advocates desire that Federal appropriations, either alone or in combination with state appropriations, should be used for building through roads, such as the much advertised Lincoln highway from ocean to ocean, the north and south road from Quebec to Miami, Fla., or the "Meridian" highway from Winnipeg to the Gulf. Many also favor the scheme of the National Highway Association, of which Mr. Charles Henry Davis is President, which proposes the construction by the Federal government of 50,000 miles of main highways, forming a network covering the entire United States.

It was against this last proposal that Congressman Shackleford particularly directed his artillery. Taking in the first place, Mr. Davis' estimate that the proposed 50,000 miles, built in the permanent manner that such main roads would require, would cost an average of $20,000 a mile, making a total cost of $1,000,000,000, he set the probable amount which the Federal government would devote to such an enterprise at not more than $25,000,000 a year, at which rate it would require forty years to complete the total 50,000 miles of roadway. Mr. Shackleford declared, however, that these 50,000 miles when built would benefit chiefly the automobile owner and the city dwellers and not the farmer, whose need of good roads was greatest. In fact, he plainly intimated that the chief motive force behind this particular appeal for Federal aid was the commercial interest of the automobile manufacturers and of the dealers in road material and road machinery. It was noticeable that this portion of Congressman Shackleford's speech did not receive tumultuous applause.

As to what constructive policy Mr. Shackleford would adopt in place of that he criticized, his address was not clear. However, instead of waiting forty years to complete 50,000 miles of good roads in the whole United States, he declared himself in favor of the policy of "improving a million miles of country highway in five years." As he also opposed large bond issues by the Federal government, however, it was apparent that the plan he favored was the improvement of ordinary earth roads; and he mentioned, with high approval, the recent good-roads rally days in Missouri and Arkansas.

Replies to Mr. Shackleford's attack were made by Edward H. Butler, of Buffalo, owner of the *Buffalo Evening News*, and by Congressman Borland, of Kansas City, Mo. Congressman Borland particularly attacked Mr. Shackleford's attitude on Federal Aid and defended Federal Aid to road construction on the ground that it would tax the city dwellers to aid in building country roads and also the wealthy States of the East to build roads in the poorer agricultural districts of the West.

Prof. Chas. T. Terry, Dean of the Columbia Law School and Chairman of the National Legislative Board of the American Automobile Association, made the concluding address, in which he strongly urged unanimous support of ex-Senator Jonathan Bourne's scheme for

Federal aid to state highway work. As our readers will recall, the Bourne scheme proposes the issue of Federal bonds to the amount of $3,000,000,000, bearing 3% interest, to be allotted to the several States which will, in exchange, give their own bonds, bearing 4% interest.

It is noteworthy, however, that so far from the Bourne scheme receiving the unanimous approval for which Mr. Terry appealed, at a later session of the Congress, Hon. J. M. Lowe, of Missouri, President of the National Old Trails Association, attacked the Bourne scheme most vigorously. He declared that the farmers of the country would never approve the creation of a $3,000,000,000 national debt for good roads; and further, that the division of responsibility between Federal engineers and State engineers, provided for in the Bourne Bill, was a fatal defect. The afternoon session was devoted to State road legislation and management.

The sessions held on Wednesday were of most interest to engineers, the subject considered being road construction and maintenance. These sessions were presided over by Mr. A. N. Johnson, State Highway Engineer of Illinois. Four of the leading papers presented at this session are published nearly in full elsewhere in this issue, the subjects and authors being "Unsurfaced Roads," by W. S. Keller, State Highway Engineer of Alabama; "Treatment of Worn Out and Raveled Macadam Roads," by Col. E. A. Stevens, State Highway Commissioner of New Jersey; "Culverts and Bridges," by A. R. Hirst, State Highway Engineer, of Wisconsin; and "Brick Roads," by James M. McCleary, County Engineer of Cuyahoga County, Ohio.

Among others who took part in the discussions were Messrs. Geo. W. Cooley, State Highway Engineer of Minnesota; and S. Percy Hooker, who was a member of the New York Highway Commission appointed by Governor Hughes, and is now State Highway Commissioner of New Hampshire. Mr. Hooker especially discussed gravel-road construction in New Hampshire. He declared that under the conditions existing there, the gravel road was far superior to the waterbound macadam. In fact, a well built and well maintained gravel road was preferred by automobile drivers to a macadam road. Other experienced road engineers who took part in the discussion expressed a similar view. Mr. R. Keith Compton, Chairman of the Baltimore, Md., Paving Commission, described the great work in progress there, under which the city is spending some $10,000,000 on the work of repaving its principal streets.

At a brief session in the afternoon, under the chairmanship of Mr. J. R. Wemlinger, Secretary of the American Society of Engineering Contractors, an important paper was read by Wm. L. Bowman, of New York, in which he pointed out the great risk a contractor runs in many states, in taking State contracts for road or other work, through the absence of any means by which money can be legally collected from the State. Only a few States have established Courts of Claims in which the just claims of contractors and others against the State can be adjudicated.

Following this session came a session of the Finance Section, before which papers were read on Bond Issues for Road Improvement and on Highway Accounting. The afternoon closed with a session of the Economics Division, with Dr. Joseph Hyde Pratt, State Geologist of North Carolina, in the chair. The session heard papers by Mr. Henry G. Shirley, Chief Engineer of the Maryland State Roads Commission, on "Systematizing the Purchase of Road Material and Equipment," and by Capt. P. St. J. Wilson, State Highway Commissioner of Virginia, and Mr. W. E. Atkinson, State Highway Engineer of Louisiana, on the "Use of Convict Labor in Road Construction."

The session on Thursday was presided over by Hon. John F. Carlisle, Chairman of the New York Highway Commission, who made a general statement of the policy which he proposes to pursue in connection with the further highway work under New York's new 50,000,000 bond issue. The most notable address of this session was made by Mr. N. G. Hall, of the Legislative Committee of the National Grange, who expressed very forcibly the attitude of this leading farmers' organization with reference to road improvement. Mr. Hull declared that the farmer is in favor of road improvement; but he is strongly opposed to such work being done by large bond issues and also to the spending of an undue proportion of either Federal or state appropriations upon roads for the benefit of automobile tourists and city and suburban dwellers, to the neglect of the ordinary country roads on which the farmer must rely for marketing his produce.

Proceedings on Friday were in charge of the Michigan State Good Roads Association. A Trunk Line Highway System covering the whole State, was laid out by the last session of the Michigan legislature. As an amendment to the State constitution, permitting the State to raise money by bond issues, for the construction of roads, is to be voted upon at the election on Nov. 14; this pending issue gave especial interest to the proceedings of the day.

Of at least equal interest to most of the members with the technical sessions of the congress was the large exhibit of road materials and machinery, in which over a hundred firms participated. The exhibit was well arranged and instructive, and was given careful study by the engineers present. Among the exhibits which aroused most discussion was the Detroit "paving determinator." As already described in ENGINEERING NEWS, this consists of a pair of heavily loaded wheels which are driven by power around a circular track. Attached to each wheel are horseshoe-shaped rammers which by spring action are made to strike a succession of blows upon the pavement as the wheels revolve. Studs attached to this rammer are supposed to imitate the action of a horse's calks upon the pavement surface. In the exhibit, part of the circular track was laid with concrete paving and the remainder with brick paving, part of it laid on a mortar bed and part laid upon sand. Such a test, made under entirely impartial control and with the conditions of foundation, setting, etc., so as to permit each type of pavement to be in good shape to resist the test when it is undertaken, might possibly give some valuable information. The time required for any such investigation, however, and the difficulties in making any such test fairly represent the varied conditions which street or roadway pavement must meet in service, seem to us to make the test of little practical use.

One of the notable features of the exhibit was a continuous performance of moving pictures, conducted by the Barber Asphalt Paving Co., showing the mining of asphalt from the Trinidad and Bermudez asphalt lakes, its handling and transportation, and the laying of the material for roads and pavements.

American Road Congress Papers

Treatment of Worn Out and Raveled Macadam Road Surfaces

By Col. E. A. Stevens*

The word "raveling" is used rather loosely. For my purpose I shall consider it as the loosening of the bond of a road surface until the macadam stone lies loose on the road. By macadam stone, I mean, not the small stone used to fill voids and give a smooth finish to the surface, but the stone that constitutes the body of the road's surface. In macadam work this stone when compressed to its final form occupies about 60% of the volume of the road surface. The 40% of voids is filled in varying proportions with surface stone, screenings, stone dust, sand, earthy materials and any chemical binder used to "hold the road."

Let us briefly consider the forces a road surface must withstand.

A draft horse weighing 1200 lb. will have all his weight at one time on two feet. He will exert, say, one horsepower at a speed of four miles. The vertical force at the foot is 600 lb., the horizontal $\frac{23{,}000}{2 \times 4 \times 88} = 33$ lb. These forces are or may well be concentrated on a toe calk 2 in. in width; the resultant force slightly exceeding 300 lb. per linear inch.

A motor truck weighing, loaded, 16,000 lb. and exerting at the wheel rims, say, 30 hp. at 10 miles an hour, will with 60% of load on rear axle, exert a vertical force of 4800 lb. and a horizontal of 562.5 lb. at each rear rim, the resultant being about 800 lb. per lineal inch for 6-in. tire.

For a pleasure car weighing 4000 lb. with 60% of weight on rear axle and exerting 40 hp. at the wheel rims with a speed of 35 miles, the vertical force at each wheel is 1200 lb. and the horizontal 214 lb. The resultant is about 400 lb. per linear inch for a bearing width of 3 in.

The binder of the road loses weight as it parts with moisture; besides this, without moisture it also loses, not only its property of recementing itself under pressure but to a great extent, its binding power as well. The real work of transmitting the stresses due to traffic must be borne by the stones. These are merely held in place by the binder. The latter is gouged out by the horse, drawn or pushed out by the automobile tire, blown away by the wind, or washed off by the rain and a loosening of the upper stone results.

Even on a well consolidated road, climatic stresses impose a heavy duty. If, however, there be voids the risk of failure increases. Voids may be due to deficient rolling or to the rise of too much clay in the earthy binder. Lumps of this material will bridge the space between stones even under hard rolling. The bridge will break down eventually either from pressure or moisture or a combination of them. A void forms where the bridge was and continues rising until near the surface, when raveling results. The same may be true in the cases of too light rolling.

When bituminous material is used as binder it is liable to disintegration from weathering, from overheating or from admixture of earthy materials.

An ordinary water-bound macadam may lose material by wear up to a thickness of about a half an inch a year without being overloaded. The thickness that can thus be lost will vary with conditions, one of which probably is the ratio of the maximum wheel load to the total tonnage borne by the road. Whatever the rate of waste it must be replaced if the road is to be maintained.

Poor workmanship in construction can only be cured by remedying the original defects. These generally show themselves by small local depressions in the surface from which raveling spreads, in certain cases at an almost incredible speed. In bituminous surface faulty material and thin spots generally show up clearly. In both cases the only remedy is to rebuild the work properly, if necessary, from the subbase up. This is not strictly repair work.

In considering the effect of overloading and neglect it must be borne in mind that any given type of construction may be so maintained as to vastly increase its carrying capacity. The problem is largely one of economics and administration. As an illustration, assume in two cases the same foundation—let one road have a water-bound macadam surface dressed with a heavy bitumen forming a sheet about ½ in. in thickness and the other a bituminous concrete (mixed method) surface of, say, 2 in. The former will cost about 40c. for stone and 15c. for dressing, or 55c. per sq.yd., and the latter about $1 (both exclusive of the foundation). With proper care the lighter surface will last about three years under fairly heavy traffic, the heavier one an unknown period, but let us assume 12 years. The total yearly charges against the two may then be stated about as follows:

Dressed Macadam:			
Interest on cost	55c.	@4%	2.2c.
Depreciation	¼ of 15c.		.5
Labor (patrol system)			1.9
Materials, stone ⅝ cu.ft.	@9c.		3.4
Bitumen ⅛ gal.	@12c.		1.5
			14 Total
Bituminous Concrete:			
Interest on cost	$1	@4%	.4
Depreciation	$1/12		.8.3
Labor			0.9
Material			0.8
			14 Total

The fixed charges are 7.2c. against 12.3c. The operating charges 6.8c. against 1.7c.

I do not claim that these figures are more than illustrations of the principle involved. They show a saving in operating charges, those that show up in the yearly tax bill. The fixed charges, however, are just as real and must be met at some date.

For a road with 9500 sq.yd. per mile the costs, as shown in yearly tax charges, where depreciation and interest are not visible, would in this case be,

For the dressed macadam, per mile.....$636.50
For the bituminous concrete..... 161.50

yet as shown above the real cost of the two roads is the same. This case affects our subject because the treatment of a raveled road surface must depend on the system of maintenance.

In most communities the great consideration is the next yearly tax bill. If that can be kept down for a period the ultimate economy of such a policy receives but slight attention. It is generally easier to get money for a new road than for repairs. A road requiring a large yearly repair charge is condemned without a hearing. The road calling for heavy interest and depreciation charges may be an equally or even more expensive solution; but the interest charge is not so apparent and the depreciation charge is not made. This is simply putting off the day of reckoning which is sure to come. However, the troubles of those in charge ten years hence are usually lightly borne by the officials of today.

In the case of a raveled road, having first determined that the road was well built, we must decide whether the traffic is too great for the type of surface, or whether the failure was due to neglect. If the former, we must resurface with some better type. If the latter, we can repair the old surface.

Resurfacing should always be preceded by scarifying and by bringing the road up to the necessary depth of stone. For water-bound macadam needing greater surface strength, several classes of chemical binder may be used, of which I shall discuss two, bitumen and lignin.

The bitumen may be applied by penetration or mixing methods. The former is the cheaper, the latter the more trustworthy. Which method is to be used will, after consideration of the care the road will receive, depend on the estimate of the overload, as will also the depth of the bituminous sheet. My own observation leads me to question the wisdom of attempting to get any thickness exceeding ½ in. by penetration methods. It also leads me for this class of work to prefer tar to asphalt. The former material appears less sensitive to injury by dirt and to yield better results in repair work.

The lignin binders are derived from the waste products of wood pulp or tannin manufacture. They are used to bind core sand in foundry work and impart a tensile strength to road-binding materials. They will not act on materials soaked in the so called road oils. The action of some of these materials on slag and red shale is quite remarkable. They are slightly soluble in water and will, therefore, need renewal. Their application, however, is easy and inexpensive and the effect of successive applications seems cumulative, increasing not only the depth of penetration but the strength of the bond. The waterproofing of lignin-bound roads with bituminous tops has been carried out in Connecticut, but I am unable to give any facts as to the results.

*State Highway Commissioner of New Jersey.

For water-bound macadam roads which have failed through neglect a thin coat of gravel carrying some earthy matter or of screenings or coarse sand mixed with earth will usually cure cases that have not gone too far. In some of the counties of New Jersey it is usual to fill all ruts, depressions, etc., with fine stone and to give the middle of the road a coat of the same mixed with a little clay. Much of this material is wasted by being thrown off the road by the traffic, and the old ruts almost invariably reappear. This method, however, is very successful in preventing raveling. It seems a false economy to omit rolling and wet rolling, at that. The same is true of patching holes with anything but macadam-size stone. The roads treated with small stone are yearly losing depth.

A treatment of clay, without rolling, will often give astonishing results. Such treatment, however, seems only a palliative, not a cure. Roads thus treated become dusty or muddy, according to the weather, show a tendency to ravel again and are hard to properly treat with bitumens. They will, however, take the lignin binders with good results, if the dose of clay has not been excessive, or if the excess is swept off before treatment.

In closing, a word of warning as to the use of the so called cold oils may not be out of place. Those of the so called non-asphaltic class, to a greater extent than the so called light asphaltic oils, seem to act as lubricant on road materials and to foster pot holes, raveling, an dother failures. It may be possible to properly apply these materials, but if so, it is rarely done. It is certain that even slight depressions will cause a deep penetration of the road. The dust-laying qualities of the material thus absorbed are lost and its lubricating effect given the best possible conditions to get in its pernicious work. Local authorities and even private individuals seem to select roads with uneven surfaces as those on which to use these oils.

Bridges and Culverts for Country Roads

By A. R. Hirst*

Among the most important considerations affecting the construction of public roads is that of drainage. The life of every road structure depends upon the drainage given it, and the culverts and bridges necessary must be built not only to serve the purpose of drainage, but must serve also the convenience and safety of travel. The failure of a road results only in the additional expense necessary to replace it in proper condition, but the failure of a bridge results also in the suspension of travel, and if it occurs at the wrong moment, may cause considerable loss of property and possibly injury or death to those traveling the road.

For many years both the design and erection of highway bridges was practically entirely in the hands of the steel bridge companies, who used their opportunity to the utmost and decorated the landscape with structures which had little to commend them except the fat prices they brought from an unknowing public.

Within the last few years, however, many states have created highway commissions which have taken up the problem of bridge design and a considerable change for the better has occurred, both in the strength of bridge superstructures and in the foundations, more especially in the latter, which was the place where most of the older structures were especially deficient, if one point of weakness can be selected from the mass of general ineffectiveness.

A properly designed waterway structure should fulfill the following requirements:

1. Waterway sufficient to carry off promptly the water coming to it.
2. Proper foundations to bear the loads, resist undermining, and give long service.
3. Superstructure designed to bear for a long period of years any load which may legally be imposed upon it.
4. Superstructure wide enough and so constructed as to serve the comfort and convenience of travel.
5. Economy of maintenance.

A sixth factor, that of æsthetic design and fitness of the structure to the surroundings, has been and is little considered in bridge and culvert design, but will probably be demanded more and more as public appreciation of the value of pleasing design grows.

In the short compass of this paper we cannot enter into a discussion of bridge design, or give any details of any specific type of structure. We will, however, give some account of our standard practice in the state highway work in Wisconsin, and probably this will be sufficient evidence of our views as to what constitutes a proper waterway structure.

Wisconsin is a state aid state, and gives state aid to bridges and culverts as well as to road construction. All waterway structures 6 ft. and under in span are classed as culverts, and are built out of the funds available for the construction of the road. All waterway structures over 6 ft. in span are considered as bridges and must be provided for by separate appropriations, the state paying 20% of their cost instead of 33⅓% as in the case of culverts on roads.

Wisconsin has a drastic bridge law which provides that culverts under 18 in. in span must be so constructed or reconstructed as to stand without planking a load of 18 tons, and waterway structures of longer span must be designed, "in accordance with standard engineering practice," to stand a load of 15 tons without planking.

In addition to the duty of designing all state-aid bridges and culverts, the state highway commission has imposed upon it by law the duty of approving as to their safety and engineering sufficiency the plans of all bridges constructed with county aid. In the seven seasons of the existence of the Wisconsin Highway Commission and its predecessor in highway work, the Wisconsin Geological and Natural History Survey, we have designed about 1000 highway bridges of a span exceeding 10 ft. for counties, and about 400 bridges exceeding 6 ft. in span, and innumerable culverts of smaller span for the state-aid construction. In addition to this, we have approved the plans for probably 500 bridges not designed by our engineers, but simply checked as to engineering sufficiency. Actual culvert and bridge construction under our own designs has cost about $2,000,000.

We may roughly divide our bridge superstructures into five classes as follows:

Class 1. Spans from 18 in. to 10 ft. Almost invariably constructed of reinforced concrete of the slab type. We are building even the smallest culverts of reinforced concrete, as we find in Wisconsin that they are entirely serviceable, easily constructed, and in probably 50% of the cases cost less than any other type of culvert except wood, which is not allowed on any of our work. The smallest concrete structure we are now building is 18x12 in., as we have found the smaller sizes equally as expensive and very easily blocked with ice and débris.

In some cases where the foundation conditions are extraordinarily soft and difficult, or concrete materials are not reasonably available, we use culverts of corrugated metal with concrete or stone end walls, but such culverts are used only where it is impracticable to use concrete, and probably not 1% of our culverts are now built of this material. Vitrified clay pipes are not used at all on state-aid work, as they have been found almost invariably to crack by filling and freezing. Concrete pipes molded in place and afterward moved to the job are not used for the same reason. Under conditions favorable to their use, both make excellent culverts, and we could recommend them in less severe climates. Cast-iron water pipe has not been used on account of its cost, which invariably exceeds that of concrete.

We find in the small concrete culverts from 18 inches to 10 feet the average cost per cubic yard complete, including the excavation and back-filling, is about $8, and very seldom runs above $10 per cubic yard; sometimes as low as $6.

Class (2). Spans 10 ft. to 40 ft.—Either reinforced concrete, the slab type up to 18 ft. and the through-girder type up to 40 ft., or I-beam structures with concrete floors are used. We are building many true reinforced-concrete bridges, but with public lettings open to any bidder, the workmanship and finished appearance has been so poor in many cases that we are using more I-beam structures than we otherwise would. In the case of I-beams, a 5-in. concrete floor is placed on top of the I-beams, and the corrugated arch type of support for the concrete between the I-beams is but seldom used.

Class (3). Spans from 40 to 80 ft.—We are using the Warren riveted pony truss practically exclusively, though a few plate girders are being used where the conditions of hauling are favorable. All of these structures have concrete floors.

Class (4). Spans from 80 to 135 ft.—We use the riveted Pratt high truss with a horizontal top chord, also with a reinforced-concrete floor.

Class (5). Spans over 135 ft.—We use a Pratt riveted high truss with a curved top chord. Practically all of these larger spans are also built with a reinforced concrete floor. Very seldom do we use a pin-connected truss, either for Class 4 or 5, probably not once in 25 cases.

From our cost figures on all bridges so far constructed, we find that for any length span the price erected (including substructure and superstructure) figures out very

*State Highway Engineer of Wisconsin.

closely to $40 per linear foot of the over-all span. Reinforced-concrete floors average about 20c. per sq.ft. Steel in plate girder and truss spans averages from $25 to $70 a ton erected, and I-beam spans from $50 to $60 a ton erected.

We have adopted for widths for concrete culverts and bridges the standards recommended by the Association of State Highway Department, which are as follows:

First Class Roads.
- Culverts under 12-ft. span, minimum width.....24 ft.
- Slab bridges over 12-ft. span, minimum width.....20 ft.
- All other concrete spans, minimum width.....20 ft.
- Very long bridges less if necessary.

Second Class Roads.
- Culverts less than 12-ft. span, minimum width.....20 ft.
- Slab bridges over 12-ft. span, minimum width.....18 ft.
- All other concrete bridges, minimum width .....18 ft.

Third Class Roads.
- Culverts less than 12-ft. span, minimum width.....20 ft.
- Slab bridges over 12-ft. span, minimum width .....18 ft.
- Longer bridges may be, minimum width.....16 ft.

Steel bridges are built almost invariably with a 16-ft. roadway; that is, 16 ft. clear distance between trusses or rails, no matter what the class of road, although for spans under 80 ft. some 18-ft. clear roadways have been built.

Abutments under practically all structures are plain concrete, as with concrete materials as cheap as we have them in Wisconsin, and with the difficulty of getting first-class workmanship in reinforced-concrete foundations without constant inspection, we find that this is the cheapest type of abutment. Occasionally cement rubble masonry abutments are used, and once in many times driven steel I-beam piles surrounded by a concrete wall are used. The last type of abutment has been found to be very satisfactory and economical for high abutments on sandy bottoms, and has largely displaced the use of cylinders with steel backing. Steel backing is not allowed on any state-aid structure. The price of concrete in bridge abutments and piers averaged last year about $8 per cu.yd.

A large share of the trouble with bridge structures results from improperly designed foundations. A common fault is stopping work before a proper depth below stream bed is reached. Seldom should foundations extend less than 4 ft. below stream bed, and whenever doubt as to the bearing power of the soil at that point is entertained, or as to undermining from a rapid stream, they should be carried down to solid soil or thoroughly piled. All foundation work should be inspected as the excavation is made and material is placed, not necessarily by an engineer, but at least by an honest man with good judgment and backbone. All concrete work in any part of the structure should be inspected as it is placed. Inspection of steel and workmanship on it as it is erected is not so necessary, as it can be inspected and its compliance with the specifications determined after erection at the time acceptance is to be given.

As to methods of letting the work. We have found it necessary to have open competition and sealed bids on bridge work, and by asking for mailed bids on all work have established true competition and have to a large extent broken up the old system of "pooling," and combinations of the bridge agents who may be on the ground at the letting. We furnish complete plans for foundations and for reinforced concrete, I-beam and plate girder spans, and all bidders submit prices on our uniform plans. For truss spans, we furnish the truss diagram showing the stresses in the truss members and the make-up of the truss members, floor system, and principal connections, and the successful bidder submits for approval the shop drawings before fabrication is commenced. For trusses we believe the latter system is preferable to that of furnishing complete shop drawings, as it allows manufacturers to follow their standard shop practice in detailing so long as these details are satisfactory.

The proper design for culverts and bridges is an engineering problem which should always be left to engineers. Probably a state highway department can handle it more economically than can private engineers, as so many bridges will be built of one span that superstructure plans can be standardized and even the same foundation plan may fit several bridges. The cost of designing, letting and accepting bridges in Wisconsin has averaged us about 3½% of the total cost. Inspection has been paid for separately by the local units. It would probably be better to have a state inspector on each bridge, but we have gotten very good results through local inspection at probably 25% of the cost of placing a man on each job.

The Brake-Chain Broke on a heavily loaded electric car of the Scranton Ry. Co., stalled on a hill on one of the streets of Scranton, Penn., on Oct. 3. The car ran down the hill at high speed and in rounding a curve, toppled over upon its side. About 30 passengers who jumped from the rear platform were injured.

The Concrete Roads of Wayne County, Mich.

By Frank F. Rogers*

Much of value has been written in the past two years on concrete roads and pavements, but a great deal is in the nature of theoretical discussions quite largely based on laboratory experiments; hence when an opportunity is offered to make a field study of many miles of concrete roads, some of which have seen four years of service, it should not be lost.

The writer makes no claim to being a concrete expert but simply has been fortunate in having the opportunity to study at first hand, and in some detail, the behavior of a large mileage of concrete roadways in Wayne County, Michigan. This county, without doubt, has a larger mileage of concrete roadways than any other county in the United States. There are now completed in Wayne County about 65 miles of concrete highways outside the corporate limits of cities and villages.

The State Highway Department with the coöperation of the road officials of Wayne County and assisted by Prof. John J. Cox, instructor in highway engineering at the University of Michigan, has just taken up some detailed and rather minute observations of these roads which will extend over a period of years in the hope that after a while a safe estimate can be made of the probable life and cost of maintenance of such pavements as the county is now building, and under such traffic, soil and climatic conditions as prevail in this locality.

The first work in this study will be careful tarffic records covering enough time and at such frequent intervals as will give a reliable estimate of the average daily traffic for one year. The first records were taken for one continuous week, beginning Aug. 21, and a part of this record which is given in the accompanying table will be used for the purpose of the present discussion.

The next step was to start a permanent record showing the present condition of each 25-ft. section (the distance between expansion joints) of all the different roads. The observations for this record were made Sept. 2, 3 and 4 and cover 6384 sections and a little over 30 miles of road. Several pieces of road have not been taken at this time. The oldest roads were built in 1909 and the newest that were taken were built in 1912, having been down one year.

For the purpose of this record the defects in the slabs or sections have been classified as longitudinal, transverse and diagonal cracks and holes.

Woodward Ave. Road

The first mile of this road was built in May and June, and opened to traffic in July of 1909, thus giving it full four years of wear. The traffic record of this road shows a daily average of 2160 vehicles, of which 88.1% were motor driven.

The soil is clay loam, inclining a little more to sand at the northerly end. A double-track electric railway occupies the westerly side of the street. Between the railway and the concrete roadway is a very shallow gutter under which was laid a tile drain from 2 to 3 ft. in depth. On the opposite side is an open ditch, the bottom of which is from 2 to 4 ft. below the crown of the roadway.

The pavement is 18 ft. wide, has a crown of 3 in. and a blind curb 8 in. wide and 4 in. deep under the outer edges which were somewhat beveled. The concrete was composed of portland cement, crushed field stone or cobbles and sand mixed in the proportion of 1:2½:5 for the base which was 4 in. thick. The top layer was made of the same materials, using a 1:2:3 mix and was 2½ in. thick.

No very definite data can be secured to determine the wear, which seems to be slightly greater on the side opposite the railway, but measuring from some of the harder pieces of the coarse aggregate which have been worm but little, if any, we have estimated the general wear at about ¼ in., which would be an average of $\frac{1}{16}$ in. per year.

This mile was divided into sections of about 25 ft., separated by expansion joints, there being 209 sections to the mile. The most of the sections were separated by four thicknesses of tar paper separated by thin boards which it was planned to remove as the work progressed though many of the boards are still in the pavement. Four of the joints were protected by pairs of steel angle bars, separated with tar paper and placed with one leg of each angle back to back so that the other leg of each bar was flush with the surface of the concrete, thus covering a space of about 4½

*State Highway Commissioner of Michigan.

in. at the joints. The concrete wears slowly on each side of the angles leaving a raised joint that is slightly noticeable when driving over the pavement. This was an experiment which has not been repeated.

Of the 209 sections constituting the first mile on Woodward Ave., 80 showed longitudinal cracks, 32 transverse cracks and two diagonal cracks while 46 sections were recorded as having holes, making a total of 160 sections which are more or less imperfect, or 76.5+% of the entire mine.

The remaining portion of Woodward Ave., 252 sections, was built in 1910, using the same materials and the same mix. No blind curb was used and the crown was reudced to 2 in. The soil on this section is considerably more sandy, especially toward the north end.

On this portion of Woodward Ave., 29 sections have longitudinal, 22 sections transverse, and 6 sections diagonal cracks; 11 sections have holes, making a total of 68 defective sections or 27+% as compared with 76+% in the first mile.

Gratiot Ave.

On Gratiot Ave. in the season of 1910, 9000 ft. of 16-ft. concrete roadway was built. On this pavement gravel and sand were used for the aggregate and a one-layer concrete having a 1:2:4 mix was laid. The soil is a clay loam and rather heavy. This road was not completed until late in the season and was opened to travel in November. It immediately pitted and looked rough and has been covered with a surface treatment of refined tar and fine gravel. It was recovered this season, using a rather light grade of tar (Tarvia A) but it already shows some tendency to scale off. The experience in some other places leads the commission to believe that a heavier grade of tar gives better results.

Beyond this portion of the roadway 326 sections of the same width concrete were laid in 1911, reaching to the county line. Washed pebbles and sand were used for the aggregate in a 1:1½:3 mix, one course concrete 7 in. deep being laid. The records for this piece are as follows: Longitudinal cracks, 11; transverse cracks, 10; diagonal cracks, 3; holes, 6; showing a total of only 30 defective slabs, or 9.2+%. The traffic count on this road, taken at the county line, shows 507 vehicles daily, 65.8% of which are motor driven.

Grand River Ave.

On the Grand River road 61 sections of two-course concrete, the same as laid in the first mile of Woodward Ave., were built in 1909. The soil is a clay loam. The records show 11 longitudinal cracks, two transverse cracks, one diagonal crack and three holes, a total of 17 defective slabs, or 27.9 minus %. The traffic count showed 1064 vehicles, 56.5% of which were motor cars.

In 1910, 341 more sections were added to Grand River Ave. under contract, the specifications being the same as for the north end of Woodward Ave; 33 of these slabs became more or less pitted, some having quite large holes. They have been repaired by covering with refined tar and stone chips so that no defects could be observed at the time of the count; hence only 308 are shown in the table. The defects noted are as follows: 59 longitudinal, 20 transverse, 29 diagonal cracks and 46 holes, a total of 154 defective slabs, or 50%.

In 1911, 515 additional sections of one-course concrete were placed on the Grand River Road. Washed pebbles and sand were used for the aggregate with a 1:1½:3 mix. The Baker steel joint was used in all of this work except the first six sections. The defects noted are as follows: Longitudinal cracks, 8; transverse, 26; diagonal, 3; and holes, 5; making a total of 42 defective sections, or 8.2+%.

In 1912, 1208 more sections were added to Grand River Ave., reaching to the line between Wayne and Oakland Counties. The count on these sections shows as follows: 66 longitudinal cracks, 37 transverse cracks, six diagonal cracks and five holes, making a total of 114 defective sections, or 9.4+%. The soil grew more sandy as the road extended westerly, considerable stretches being almost free from clay or loam.

Michigan Ave.

On Michigan Ave., 481 sections of concrete, 17 ft. 8 in. wide were laid, using washed pebbles and sand for the aggregate in a 1:2:4 mix. The soil for the most part is a sandy loam, but a little heavy. The count shows as follows: 219 longitudinal cracks, 48 transverse cracks, 23 diagonal cracks, 21 holes, maknig a total of 311 defective sections, or 64.6 +%. The traffic count shows 1009 vehicles, 67.5% of which were motor driven.

In 1911, 1570 sections were added to this piece of road, using washed pebbles and sand for the aggregate and a 1:½:3 mix. The soil over which this pavement was laid is a sandy loam running into light sand at the west end. The count shows the following: 219 longitudinal cracks, 80 transverse cracks,, 42 diagonal cracks, 14 holes, making a total of 355 defective sections, or 22.6+%. In 1912 this road was paved to within 1¼ miles of the county line, and

WAYNE COUNTY CONCRETE ROADS

Name of road	Number of 25-ft. sections	Width, ft.	Depth, ins.	Aggregate	Mix	Year built	Soil built on	Traffic count 24 hrs. Average 1 week	% Motor driven	% Horse vehicles	Defective Sections: Longitudinal cracks	Transverse cracks	Diagonal cracks	Holes	Total number	Total %
Woodward Ave...	209	18	6½	Crushed cobbles Sand	1-2½-5 1-2-3	1909	Clay loam	2160	88.1—	11.9+	80	32	2	46	160	76.5+
Woodward Ave...	252	18	6½	Crushed cobbles Sand	1-2½-5 1-2-3	1910	Sand loam				29	22	6	11	68	27.0—
Gratiot Ave.....	326	16	7	Washed pebbles Sand	1-1½-3	1911	Clay loam	507	65.8+	34.2—	11	10	3	6	30	9.2+
Grand River Ave.	61	18	6½	Crushed cobbles Sand	1-2½-5 1-2-3	1909	Clay loam	1064	56.5+	43.5—	11	2	1	3	17	27.9
Grand River Ave.	308	16	6½	Crushed cobbles Sand	1-2½-5 1-2-3	1910	Clay loam				59	20	29	46	154	50.0—
Grand River Ave.	515	16	7	Washed pebbles Sand	1-1½-3	1911	Sand loam				13	26	3	6	48	9.3*
Grand River Ave.	1208	16	7	Washed pebbles Sand	1-1½-3	1912	Sand loam	352	66.5—	33.5+	70	44	13	5	132	10.9*
Michigan Ave....	481	17'-8"	6½	Washed pebbles Sand	1-2-4	1910	Clay loam	1009	67.5+	32.5—	219	48	23	21	311	64.6+
Michigan Ave....	1570	18 16	7	Washed pebbles Sand	1-1½-3	1911	Sand loam				219	80	42	14	355	22.6+
River Road.....	149	15	6½	Washed pebbles Sand	1-2-4	1910	Clay	538	78.9+	21.1—	49	5	6	2	62	41.6+
River Road.....	434	15	7	Washed pebbles Sand	1-1½-3	1911	Clay				165	17	13	0	195	44.9+
River Road.....	213	15	7	Washed pebbles Sand	1-1½-3	1912	Clay				14	8	4	0	26	12.2+
River Road.....	208	15	7	Washed pebbles Sand	1-1½-3	1912	Clay				17	9	0	0	21	10.0+
Fort St. Road....	450	12	7	Washed pebbles Sand	1-1½-3	1912	Clay				0	19	9	1	29	6.5—

*Corrected Sept. 22, 1913.

this year completed to the county line, but no record was taken farther west than the east limits of the village of Wayne.

River Road

In 1910, 149 sections of concrete 15 ft. wide and 6½ in. deep were laid on the River Road, using gravel and sand for the aggregate and a 1:2:4 mix. The soil over which this road runs is for the most part heavy clay. The count shows as follows: 49 longitudinal cracks, five transverse cracks, six diagonal cracks and two holes, making a total of 62 defective sections, or 41.6+%. The traffic count shows 538 vehicles daily, of which 78.9% were motor driven.

In 1911, 434 sections were added to this road some distance below the village of Trenton. The pavement was 15 ft. wide, 7 in. thick, built of washed pebbles and sand for the aggregate, using a 1:1½:3 mix. The count for this stretch of road shows as follows: 165 longitudinal cracks, 17 transverse cracks, 13 diagonal cracks and no holes, a total of 195 defective sectfons, or 44.9+%.

In 1912, the gap between this piece of road and the southerly limits of the village of Trenton was closed in with a similar pavement to that just described, comprising 213 sections. The count on this piece shows defects as follows: 14 longitudinal cracks, eight transverse cracks, four diagonal cracks and no holes, making a total of 26 sections, or 12.2+%.

The same year there was added to the south end of the work done in 1911 something over two miles of concrete roadway, but of this only 208 sections were counted. Of the sections counted, 17 show longitudinal cracks, nine transverse cracks, no diagonal cracks and no holes, a total of 21 defective sections, or approximately 10%. The soil of the entire road was heavy clay.

Fort Street Road

In 1910, one-half mile of gravel concrete of a 1:2:4 mix, 12 ft. wide and 6½ in. deep was built on Fort St. This concrete, like that already referred to on Gratiot Ave., was built rather late in the season and was opened to traffic in November. It immediately pitted to such an extent that it has since been coated with refined tar and fine washed gravel, about ¼ in. in size. This covering makes an excellent surface and wears fairly well. Of course, it was impossible to observe any further defects in the concrete at this time. Continuing south, in 1912, 450 sections of concrete 12 ft. wide, 7 in. deep, and of 1:1½:3 mix were added. The count on this piece of road follows: Longitudinal cracks, none, although another observer has reported there are two, transverse cracks, 19; diagonal cracks, nine, and holes, one. Total defective sections, 29, or 6.5—%.

From the foregoing, it is strikingly apparent that the percentage of defects varied greatly in the different roads. A careful study of this variation in connection with the age of the pavement will soon convince one that mere age has not produced the defects noted. For example, 252 sections built on Woodward Ave. in 1910 show but 27% defective slabs, while 308 sections built on Grand River Ave., the same year under the same specifications, show 50% of defective slabs. There are two noticeable differences. Grand River Ave. was built by contract on a clay-loam soil while the portion of Woodward Ave. named, was built by day labor under the direct supervision of the engineers of the County Road Commission, on a soil more sandy and, presumably with a little better sub-drainage. Again, 481 sections built on Michigan Ave. the same year with sand and pebbles for the aggregate and at 1:2:4 mix show 64.6% of defective slabs. This was on clay-loam soil. We might also mention 149 sections built on the River Road in 1910 on heavy clay soil, under the specifications last named, which show but 41.6% of defective slabs.

The most noticeable feature concerning these defects is that the longitudinal cracks almost always appear in groups, seldom singly. This indicates that there must be some local conditions in the foundation, due to insufficient drainage, soil conditions, newly made fills or uncompared sub-grades that cause these defects. Longitudinal cracks almost invariably appear on fills and on cuts, apparently with as much frequency in the latter as in the former. It would seem that cracks on the fills are due to the settlement of the embankment, and in the cuts the presence of water and frost in the sub-grade. Briefly, the writer's opinion is that these cracks are due, first, to the settlement of the newly made fills, and, second, to water that has not been completely removed from the sub-grade, plus frost If these causes could be thoroughly eliminated it would seem possible to build concrete roadways to the width of 15 or 16 ft., where sufficient expansion joints are used, without fear of trouble from longitudinal cracks.

It has been argued by the Morse-Warren Engineering Co., in a recent publication, that it is impossible to build concrete pavements wider than 12 ft. which will remain free from longitudinal cracks without using longitudinal joints, unless the pavement is so thick as to make the price practically prohibitive. The table accompanying this report which shows 450 sections of 12-ft. roadway on the Fort St. road would seem to bear out this assertion, but a mile of concrete on the Eureka road, which the writer did not get time to inspect, shows a great number of longitudinal and transverse cracks in a 12-ft. concrete roadway, where the soil conditions are the same as on the Fort St. road referred to. The only apparent difference is that the former is a 1:2:4 mix and the latter a 1:1½:3 mix, washed pebbles and sand being used for the aggregate in both cases.

But long stretches of pavement 16 ft. wide and now two years old on Grand River and Michigan Aves., which show no longitudinal cracks, would seem to prove that this statement is not necessarily true and that a sufficient amount of money spent in compacting and draining the foundation or in reinforcing the concrete over newly made fills, would produce pavements free from the objectionable longitudinal crease, whether natural or artificial. Most persons are agreed that transverse cracks are almost always due to defective expansion joints. It has been thoroughly demonstrated, both theoretically and practically, that 25 ft. is frequent enough for the expansion joints, and it is quite possible that they might be placed farther apart with safety —probably not less than three to 100 ft.

The diagonal cracks are doubtless due to causes which are a combination of those noted under longitudinal and transverse cracks. Many diagonal cracks were noted where the corners only were broken off, frequently on adjoining corners of adjacent slabs, indicating that the slabs were united through the expansion joints with a bond stronger than the tensile strength of the concrete on either side of the joint.

The holes noted are perhaps of less importance than the different kinds of cracks. In a few instances they are rather large, sometimes a square yard or more in area, but such places are very rare and most of the holes noted are due simply to some foreign substances getting into the concrete, like clay, wood or some fragment of an inferior rock that might chance to be a part of the aggregate. This was more noticeable where crushed cobbles were used for the coarse aggregate than where washed pebbles were used.

Anyone familiar with the quality of rocks which constitute Michigan cobbles will understand that the principal objection to this material for an aggregate on concrete roads is the varying qualities of these rocks, ranging from soft to hard granite, quartzite and trap. A study of the roads where these materials have been used shows much more wear in the spots where the softer rocks happen to be at the surface.

Up to the present time the defects noted, except the pitted conditions of the concrete roads which have been resurfaced in the manner already described, are not serious and are not causing any additional expense for upkeep. In the past two years the expansion joints on all the old work, whether reinforced or not, have been coated with refined tar and sand once a year. Thus far, the cost has ranged between $50 and $100 per mile, depending on the distance of the work from the base of supplies. These repairs are proving adequate and satisfactory, and while the defects noted are something of a reflection on the present method of building concrete roadways they are really no reflection on the use of concrete as a suitable material for making hard and durable surfaces over our country highways wherever traffic conditions warrant, and the community has the ability to pay the cost of high-class road surfaces. There is no question as to the necessity of some form of very permanent roadway near the city of Detroit, neither is there any question as to the ability of Wayne County to pay for a roadway that is good enough and permanent enough to meet the requirements of its traffic. In the writer's opinion, Wayne County has made no mistake in choosing concrete as a paving material for its main roads.

A Motor Truck was recently driven in Alaska from Valdez to Fairbanks and return, a distance of 826 miles, in 19 days. The vehicle used was a White, 1500-lb. capacity, motor truck, and the trip was an experimental one made under direction of the Alaska Board of Road Commissioners. The truck was started from Valdez on July 28, carrying a full load of supplies and mail for camps along the military telegraph line. Many difficulties were experienced with snow slides, melting snow and ice, and soft mud in the swampy sections. In places it was necessary to wind the wheels with rope to secure traction. The northbound trip was made in nine days, the total distance being 379 miles. Fairbanks is located at the head of navigation on the Yukon and is only two degrees

south of the Arctic circle. On the return trip the truck was loaded with 2100 lb., 600 lb. in excess of its capacity. A detour of 68 miles to Chitina was made on the return journey, lengthening the trip to ten days.

The Commission Plan of Municipal Government was defeated at Minneapolis, Minn., on Oct, 1. The adverse majority is reported as 13,149.

An Ammonia Pipe Exploded in the engine room of the Sherman Square Hotel, New York City, on Oct. 5. The engineer was overcome by the fumes, but was resuscitated.

The Union Station Burned, at St. Paul, Minn., on Oct. 4. The buildings is a three-story frame structure; the loss is estimated at $250,000. The fire according to press dispatches, is believed to have originated in the kitchen of the station restaurant.

Three Electric Cars Jumped the Rails while passing over a bridge, Sept. 17, near the village of Villeneueve-Loubet, France, and fell 40 ft. into a ravine. According to press dispatches, the cars were filled with passengers, of whom 12 were killed and 30 injured.

Two Slides of Rock on the Lexington Ave. subway work in New York City killed two men and injured two others, on Sept. 29. The first occurred near 92d St., where about a cubic yard of rock was displaced; in the second instance a 2-ton rock fell into the subway near 125th St.

Monoplanes Were Faster Than Biplanes in the cross-country race for both classes of aëroplanes at Rheims, France, Sept. 28. The race was five times around a 18.6-mi. course. The best time was made by a monoplane (1 hr. 7 min. 18 sec., or at the rate of 84 mi. per hr.). The fleetest biplane finished in 1 hr. 35 min. 51 sec.

The New Dry Dock of the Port of Boston we now find is of the dimensions noted in our issue of Aug. 28, 1913, p. 435, and not those noted in our issue of Sept. 25, 1913, p. 635. These dimensions are as follows: Total length over all, 1200 ft.; available docking length, 1162 ft.; bottom entrance width, 120 ft.; depth over sill, 44.8 ft. at mean high water.

Electric Traction will supplant steam for the suburban service on the Germantown branch, New York division, of the Pennsylvania R.R. out of Philadelphia, for a distance of 12 miles to Chestnut Hill. This work is undertaken in connection with the electrification of the main line to Paoli (as noted in "Engineering News," Apr. 3, 1913, p. 656) as offering the quickest effective way of increasing the passenger capacity of the suburban service into Broad St. Station, Philadelphia. The work of equipment will be completed by the fall of 1914, and the expenditure is estimated to approach $1,250,000 (in addition to $4,000,000 for the work to Paoli). It is reported that the energy supply will probably be purchased from the Philadelphia Electric Co.

The Schedules of about 1300 Trains Have Been Revised by the management of the New York, New Haven & Hartford R.R., to take effect Oct. 5. Those chiefly affected are the through trains and the long-distance locals. The time of the limited trains between New York and Boston now will be 5 hr. 10 min., instead of 5 hr. as heretofore, making the average speed of these trains (exclusive of stops) 47.8 mi. per hr. Between New York and Springfield, Mass., and New York and Pittsfield, Mass., from 3 to 25 min. have been added to the previous running time of trains. Upon those lines where the block system is not in use, the new schedules prescribe 10 min. as the minimum time between trains. This railroad operates 2000 trains per week-day, so that the schedules of two-thirds of these have been changed.

The Proposed Hetch Hetchy Water-Supply for San Francisco, now before Congress in the form of a bill authorizing a dam and right-of-way in the Hetch Hetchy Valley, was approved by the House on Sept. 3, by a vote of 183 to 43. On Sept. 24, the Public Lands Committee of the Senate voted unanimously to report the bill favorably. The bill has been modified to meet demands from irrigation districts whose water rights are involved and it is stated that the Spring Valley Water Co. is no longer fighting the bill. This leaves as the only opponents of the scheme certain interests which wish the city to buy water or alleged water rights from them and also those who urge that it would be a shame to flood the Hetch Hetchy meadows, which are a part of the Yosemite National Park though quite distinct from the Yosemite Valley. The Senate later agreed to take a vote on the measure between Dec. 1 and 6, 1913.

Several Earthquake Shocks occurred in the Canal Zone on Oct. 1-2, reported to have been the most severe since American work on the Isthmus began. An official statement from Panama, Oct. 2, states that the first shock was noticeable only on the seismograph at the Ancon observatory. The next and greatest shock was felt about 10 hours later and is estimated to have lasted 20 seconds; the exact duration of this quake is not known because the pen of the seismograph was thrown from the chart. During the next six hours 11 other tremors were recorded. The center of disturbance appears to have been somewhere to the north of Colon in the Caribbean Sea. No damage was done to the canal and no walls were affected in the city of Panama. In the province of Los Santos the governor's residence and a church were wrecked.

The Headings of the Catskill Aqueduct Tunnel Under East River, New York City, met on Sept. 27. This most interesting link in the great water-supply tunnel under the entire length of the Borough of Manhattan and a part of the Borough of Brooklyn was completed late Saturday night with no other ceremony than the presence of the Department Engineer in charge of the city tunnel, Walter E. Spear, and the Division Engineer, Lazarus White, under whose immediate supervision this part of the work came. The meeting of the headings occurred about 750 ft. below the river level and marks the beginning of the end of what has been the most difficult part of the deep tunnel project. The alignment met within 0.17 ft. and the stationing within 0.03 ft. Of the whole aqueduct from the Hillview reservoir to Atlantic Ave., Brooklyn, there remains a little more than half a mile to be excavated. The city tunnel of the Catskill aqueduct was planned in the fall of 1909 (See "Eng. News," Dec. 9, 1909, p. 652) and was reported upon by Messrs. Clemens Herschel, Francis L. Pruyn and J. Edmund Woodman, on May 14, 1910 ("Eng. News," June 2, 1910, p. 655). The scheme was authorized by the Board of Estimate and Apportionment in July, 1910, and approved by the State Water Supply Commission in October, which was the last legal obstacle to overcome. Contracts were let and work begun early in 1911. The work was without precedent in city water-supply distribution systems and its quick completion according to the engineers' plans and estimates is a notable engineering achievement.

Large Landslides occurred on the British Columbia Division of the Canadian Pacific Ry., on Sept. 4. The most serious was at mile 24.83 on the mountain subdivision, blocking the track and stopping traffic for some time. When the trackwalker arrived at this point about 7:30 a.m., on Sept. 4, he noticed a small quantity of mud and boulders on the track. While putting out his flags the quantity of sliding material increased and kept coming down for over two hours. Rain fell in intermittent showers on Sept. 2 and 3 and during the night on the latter date nearly assumed the magnitude of a cloudburst.

A small creek which comes down at this point passed under the track in a 4x5-ft. culvert. It had never been considered a dangerous stream but subsequent examination showed that on the upper levels the heavy rainfall started several log jams which tore their way down the creek bed, dislodging large quantities of mud and boulders from the sides of the creek.

The head waters of the creek are about 3500 ft. above the railway and 2½ miles distant, and when once these log jams on the upper portions of the creek were dislodged, further accumulations of débris were formed although at no point in the creek was there sign of any large slide having dammed up the creek. Boulders as large as 700 cu.ft. were carried down onto the tracks, and slide material was deposited to a depth of 25 ft. above the rails. The track itself was not damaged and two steam shovels were set at work as soon as possible and cleared the material away.

Competitive Plans for a Seaside Park for the Borough of Queens, New York City, are invited. The plans must be in the hands of W. G. Eliot, Commissioner of Parks, Borough of Queens, Richmond Hill, N. Y., on or before noon of Nov. 1, 1913. It is expected that the committee of judges will consist of five members, including Mr. Eliot, Nelson P. Lewis, Chief Engineer of the Board of Estimate and Apportionment, New York City, and Arnold P. Brunner, the New York architect. The competition is to be open to landscape architects and landscape engineers generally. Prizes of $500, $200 and $100 are offered. Competitors must submit a general plan or map on a scale of 80 ft. to the inch, or such scale as may be employed by the topographical map furnished to the competitors by the Park Commissioner. The plan must be accompanied by a general report and explanation, with an approximate estimate of cost, the latter to be subdivided under the headings: general regulating, grading, construction of roads, paths, and drainage; cost of changing present shore line, including bulkheads, dredging and filling; cost of trees, shrubs, plants, seeding and sodding. The location of various buildings should be indicated, but their estimated cost need not be specified. There will be included in the park area landing piers; an interior basin for boating some twenty to twenty-

five acres in extent and a wading beach for children; parking spaces for automobiles; bath houses, pavilions and comfort stations, the bath houses to be large enough to accommodate 10,000 bathers at one time. All plans, reports and estimates will be returned to the competitors except those submitted by the persons who receive the prizes, but the rules of the competition provide that the committee may select additional plans and reports to become the property of the city on payment of $50 to each competitor whose plans are thus selected. More complete details of the competition may be obtained from Mr. Eliot by addressing him as stated above.

Electric Traction with direct current at 2400 volts has been announced for the Montreal tunnel and terminal section of the Canadian Northern Ry. There will be 10 miles of double track between the passenger and freight terminals in Montreal and the Cartierville yards, beyond the town of Mount Royal, where outgoing and incoming trains will change from electric to steam locomotives and vice versa. Multiple-unit trains also will give frequent fast suburban service into Montreal.

An order has recently been placed for seven locomotives, eight multiple-unit motor cars and complete substation apparatus. The locomotives will have an articulated running gear and will weigh 80 tons, all weight being on the drivers. Each unit will have two four-wheel trucks ,and four motors with twin gears, the motors being of a commutating-pole type, each wound for 1200 volts but insulated for 2400 volts. They are intended to be connected permanently two in series. Multiple-unit series-parallel control will be used with low-voltage switching current from a small motor-generator set. Each suburban multiple-unit motor car will have four 125-hp. motors, similarly connected and controlled. At the west portal of the tunnel will be a substation containing at first two motor-generator sets, with room left for a third. Each set will have a direct-current output rating of 1500 kw. at 2400 volts with a five-minute overload capacity of 200%. Each will comprise two commutating-pole 1200-volt direct-current generators (insulated for 2400 volts) connected permanently in series. These will be mounted on one shaft and driven by a 2100-kv.a. 11,000-volt synchronous motor. Power will be purchased at 11,000 volts (three-phase, 60-cycle). The new transcontinental line of this railway and the Montreal tunnel and terminal construction were described in "Engineering News," July 10, 1913.

The Chicago Garbage-Disposal Situation has reached the expected crisis, due to the city's persistent failure during the past two years to provide for handling the garbage after the expiration of the contract with the Chicago Reduction Co., on Aug. 31, 1913. At the last moment an agreement was made to purchase the company's plant on a valuation, the company to continue to handle the garbage for a month. Now the board of three appraisers has failed to agree upon a price. The city's representative on the board refused to allow any "going value," and the company has stated that it could not afford to operate its plant without the city's business.

The valuation of the city's representative was $208,580, while that of the other two appraisers was $492,500. On the afternoon of Sept. 30, the company sent its deeds to the city with a request for payment of the sum decided upon by a majority of the board, but the city officials declined the offer, there being no agreement to accept a majority report. The company then declined to handle any more garbage, and while it later offered to do this for ten days, the offer was refused.

At a special meeting of the council on Oct. 1, it was voted (51 to 14) to adopt the temporary expedient of dumping the garbage in clay pits, to accept the offer of free use of a dump on the south side, and to appropriate $75,000 for plant and labor necessary for the work up to January next. Doctor Young, the health commissioner, explained that he proposed to use a deodorant and to cover the garbage with the dry rubbish now being dumped at these points, and asserted that in this way the garbage could be disposed of in a "safe and inoffensive manner" pending the action of the council on some permanent system. The deodorant is a chemical solution invented by a Doctor Hirsh, who has also proposed a reduction system of his own, using this chemical in the digesters. But this process has never been used.

Many of the aldermen strongly advocated taking possession of the present plant by force, but the mayor and the health commission have opposed such a step. It is suggested that householders can help to relieve the situation by burning garbage in stoves and furnaces. The present collection averages 600 tons per day, and is estimated to average 500 tons per day for the next three months. An agitation has been started against dumping the garbage in clay pits, on account of the nuisance in the neighborhood and in the streets through which garbage is to be handled. The city has purchased sites for two incineration plants, but this does not affect the present situation.

PERSONALS

Mr. S. H. Osborne has been appointed Division Engineer of the Oregon Short Line R.R., with office at Pocatello, Idaho.

Mr. W. W. Morrison has been appointed Engineer of Maintenance-of-way and structures of the Pittsburgh & Shawmut R.R., with office at Kittanning, Penn.

Mr. J. D. Weddow, Superintendent of Construction for the City of Cleveland, Ohio, on city day-labor undertakings, has resigned to accept a position with a contracting firm.

Mr. George C. Cleveland, Chief Engineer of the Lake Shore & Michigan Southern Ry., at Cleveland, Ohio, has been made Chief Engineer of the Cleveland Short Line R.R. also.

Mr. G. H. Cumberland, recently Assistant Engineer of the Oregon Short Line R.R., at Salt Lake City, Utah, has been promoted to be Division Engineer, with office at Pocatello, Idaho.

Mr. W. M. Bosworth, formerly Chief Engineer of the Tacoma Railway & Power Co., is now in charge of a survey for a national automobile highway to connect North Yakima with Seattle and Tacoma, Wash.

Mr. Edward J. Nally, formerly Vice-President and General Manager of the Postal Telegraph & Cable Co., New York City, has now been appointed to the same offices with the Marconi Wireless Telegraph Co. of America.

Mr. S. M. Udale, formerly Assistant Research Engineer with the Studebaker Corporation, Detroit, Mich., is now in charge of the laboratory and motor-testing plant of Mr. Joseph Tracy, Automobile Engineer, 1790 Broadway, New York City.

Mr. George Paaswell, recently Designer at the head office of the Public Service Commission of New York, First District, New York City, has been promoted to be Assistant Engineer of the third district of the New York City subway and elevated lines.

Prof. E. H. Williams, Jr., M. Am. Inst. M. E., for 21 years head of the departments of mining engineering and geology at Lehigh University, was honored on Founders' Day, Oct. 4, with the degree of Doctor of Laws. Dr. Williams is now a lecturer at the University.

Mr. Timothy J. Sullivan, of Springfield, Mass., a former Roadmaster of the Boston & Albany R.R., is reported to have signed a contract with New York capitalists, to superintend the construction of 180 miles of railroad in San Domingo, at a salary of $12,000 per annum.

Mr. F. J. Herlihy, Assistant Engineer and Superintendent of Construction on the northwest extensions of the Chicago, Milwaukee & St. Paul Ry., at Great Falls and Lewiston, Mont., has been appointed Superintendent of Construction of a large hydro-electric development at Montreal, Que.

Mr. R. C. E. Weber has resigned as Assistant Engineer, U. S. Reclamation Service, to enter the employ of the California Railroad Commission at San Francisco, Calif. For the past four years Mr. Weber has been engaged on construction work for the distribution system of the Orland, Calif., Project of the U. S. Reclamation Service.

Dr. Arthur T. Hadley, President of Yale University, has been elected a director of the New York, New Haven & Hartford R.R. Dr. Hadley has made a special study of railway transportation economics; for two years he was Associate Editor of the "Railroad Gazette," and he is the author of several books on railways and economics.

Dr. Karl Imhoff, well known to American engineers as the inventor of the Imhoff tank method of sewage treatment, arrived in this country, Sept. 30, for his annual vacation trip. He is spending some time in Montclair, N. J., with Mr. Rudolph Hering, M. Am. Soc. C. E., and will probably visit Atlanta, Cleveland, Toronto and other Eastern cities before returning to his home in Germany.

Mr. Frank J. Echle has been appointed General Shop Inspector of the Lake Shore & Michigan Southern Ry., and the Dunkirk, Allegheny Valley & Pittsburgh R.R., with headquarters at the Hollingwood Shops, Ohio, succeeding Mr. Joseph J. Schultz, transferred. Mr. A. J. Krueger has been appointed Assistant General Shop Inspector with headquarters at the Collingwood Shops.

Prof. Mansfield Merriman, M. Am. Soc. C. E., was honored by Lehigh University at the annual celebration of Founder's Day, Oct. 4, with the degree of Doctor of Laws. Dr. Merriman was head of the department of civil engineering at Lehigh University for nearly 30 years and is the author of many well known engineering textbooks. Dr. Merriman is also a Doctor of Philosophy and a Doctor of Science.

Mr. E. N. Brown, whose resignation as President of the National Rys. of Mexico, was noted in our issue of July 24, has now withdrawn his resignation upon reaching a satisfactory agreement with the Mexican Government and will soon resume his former position. Mr. Brown is an engineer by early training and experience. For several years he was Division, Resident and Locating Engineer of the Central of Georgia Ry.

Mr. H. H. Quimby, M. Am. Soc. C. E., formerly Assistant Engineer, Bridge Division, Bureau of Surveys, Philadelphia, Penn., and recently acting Chief Engineer of the new Department of City Transit, has been appointed Chief Engineer as the result of a civil-service examination. For several years previous to his city work, Mr. Quimby was with the Phœnix Bridge Co. He is the designer of the Walnut Lane reinforced-concrete arch bridge, the Passyunk Ave. and many other notable bridges in Philadelphia.

Mr. E. H. Howard, M. Am. Soc. C. E., Chief Engineer of the Boston & Worcester Street Ry., a notable Eastern interurban trolley railway, has resigned to engage in private practice with offices at South Framingham, Mass. Mr. Howard graduated from the Worcester Polytechnic Institute in 1900 and began his connection with the Boston & Worcester Street Ry. as a Resident Enginer on construction in 1902. From December, 1904, to January, 1907, he was engaged in other work, but returned to become Assistant Chief Engineer. Later he was promoted to be Chief Engineer.

Mr. R. D. Garner, Assistant Engineer of the Grand Trunk Ry., at Bay City, Mich., has been appointed Superintendent of Construction of the new Southern New England Ry., the Grand Trunk Ry's. extension to Providence, R. I., on which work was stopped last fall. The work was discontinued by an agreement between President Chamberlin of the Grand Trunk System and former President Mellen, of the New York, New Haven & Hartford R.R., both of whom are now under indictment for violating the federal interstate commerce laws in this connection. Work has now been resumed, and it is stated the extension will be completed.

Mr. Everett E. Stone, M. Am. Soc. C. E., who, as we noted in our Personal column of Sept. 25, was nominated for the position on the Massachusetts' Public Service Commission made vacant by the resignation of ex-Congressman Lawrence, has had extensive railroad experience. He was born in 1856, and in 1887 became connected with the Boston & Albany R.R., with whom he remained until 1909, passing through the several grades of Surveyor, Assistant Roadmaster, Division Roadmaster, Assistant Chief Engineer, Engineer of Maintenance-of-Way and Construction, and finally Chief Engineer. He was twice elected Mayor of Springfield, Mass., and is at present Treasurer and Consulting Engineer of the North Eastern Construction Co.

Mr. J. A. Donahey, Assoc. M. Am. Soc. C. E., Assistant Engineer of the Akron, Canton & Youngstown Ry., Akron, Ohio, has been promoted to be Superintendent and Chief Engineer, with headquarters at Akron, succeding Mr. F. E. Bissell, M. Am. Soc. C. E., resigned. Mr. Donahey was born in Darrowville, Ohio, in 1878, and has been in engineering work since he was 19 years old, when he entered the employ of Mr. C. C. Smith, Engineer and Surveyor, as a chainman on surveys in West Virginia. Between 1899 and 1905 he served in a variety of subordinate positions in railway survey and construction work in the Middle West. In 1905 he was made Resident Engineer of Construction on the Franklin & Clearfield R.R. and in 1907 Resident Engineer on construction for the Lake Erie & Pittsburgh Ry.

Mr. Elwood Mead, M. Am. Soc. C. E., has resigned his office as Chairman of the State Rivers and Water Supply Commission and Chief Engineer of the Water Supply Deparment, Melbourne, Australia, to become the head of the new division of rural institutions at the University of California. This new department will study and aid rural institutions which aim to make farm life successful and satisfactory. Mr. Mead was formerly Chief of the United States Bureau of Drainage Investigations, and previous to that was State Engineer of Wyoming. For several years he has been in the service of the Victorian Government as an irrigation expert and it is probable his services in a consulting capacity will be retained. When Mr. Mead went to Australia in 1907 he left a position at the University of California similar to that to which he now returns. He will be known as Professor of rural institutions and his work will deal with the study of rural credits, the making of farm loans, the improvement of marketing methods, etc. His salary in Australia has been $10,000 per annum.

Mr. S. L. Wonson, Assoc. M. Am. Soc. C. E., formerly General Bridge Inspector, Missouri Pacific Ry., St. Louis, Mo., has been promoted to be Bridge Engineer, succeeding Mr. C. E. Smith, who was promoted to be Assistant Chief Engineer, as noted in our issue of July 24. Mr. Wonson was born in Gloucester, Mass., in 1877 and graduated from the Massachusetts Institute of Technology in 1901. After a year spent as an instructor at the Institute he served three years as a draftsman and Assistant Engineer in the erecting department of the American Bridge Co. In June, 1905, he went to Colombia, South America, where he was in charge of the locating and sinking of the cylinder piers, the construction of a temporary bridge and the preparation for erection of the superstructure, of a 225-ft. bridge for the Cauca Ry. In January, 1906, he returned to the service of the American Bridge Co., where he remained until August, 1907, as Assistant Engineer in the erecting department. From August, 1907, until his connection in 1911 with the Missouri Pacific Ry., he was Assistant Engineer in the bridge department of the Mexican Ry. Co., Mexico City.

OBITUARY

William Elliott, one of the founders of the Elliott Frog & Switch Co., East St. Louis, Ill., died Sept. 26.

William M. Larned, for ten years Assistant Engineer in the San Francisco, Calif., Public Works Department, died Sept. 20. He was a native of Baltimore, Md., and 40 years of age.

George R. Lewis, a young mining engineer, of Wollaston, Mass., died at a pleasure camp at Ballardvale, Mass., Sept. 29. He had recently returned home from Mexico on a vacation. He graduated in mining engineering from the Lawrence Scientific School, Harvard University, in 1909. He was 32 years old.

George Russell Lincoln, a mining engineer and metallurgist, and for several years Professor of chemistry at the Massachusetts Institute of Technology, died in Paris, France, Sept. 29. He was born in Philadelphia 65 years ago. As a young man he entered the employ of the Pennsylvania Steel Co., at Steelton, Penn., as a chemist. He had traveled extensively and lived in many European cities and was a writer of scientific literature.

John F. Ensign, Chief Inspector of Locomotive Boilers, Interstate Commerce Commission, died Sept. 24, at his home in Washington, D. C. He was born in 1862 at Marathon, N. Y., and as a young man went to Colorado where he began railway work as a blacksmith with the Chicago, Burlington & Quincy R.R. Later he was machinist, fireman and engineman. In 1904 he was made an inspector of safety appliances for the Interstate Commerce Commission and in 1911 was promoted to be Chief Inspector of Locomotive Boilers.

Edwin T. Moore, Secretary and Treasurer of the Coatesville Boiler Works and a director and member of the executive board of the Coatsville Foundry & Machine Co., died at his home in Coatesville, Penn., Sept. 25. He was 47 years old. Mr. Moore entered the employ of the boiler works 26 years ago and in ten years became Secretary and Treasurer. Two years later his remarkable knowledge of all the details of the business resulted in his being made General Manager. He was one of the founders of the Coatesville Foundry & Machine Co. and was prominent in a large number of Coatesville institutions.

Ebenezer T. White, District Superintendent of Motive Power of the Baltimore & Ohio R.R., at Baltimore, Md., died recently at his home in Baltimore from apoplexy. He was born at Fellowsville, Va., in 1858. In 1874 he began a four-years' course as a machinist apprentice wih the Baltimore & Ohio R.R. He was promoted successively through all the offices in the mechanical department to be Master Mechanic of the Baltimore division in 1889. Ten years later he was made Superintendent of Motive Power of the lines east of the Ohio River. Until recently he was Superintendent of Motive Power of the entire system.

Samuel B. Haupt, President and General Manager of the Susquehanna, Bloomsburg & Berwick R.R., died Sep. 28, at his home in Milton, Penn. He was born in 1849 and at 19 years of age entered the Pennsylvania R.R. shops at Altoona, Penn., as an apprentice. He was promoted to be machinist, draftsman, chief draftsman and Assistant Master Mechanic

at Altoona. Later he was Superintendent of the Roanoke Machine Works, Roanoke, Va., and Superintendent of Motive Power of the Norfolk & Western Ry. He was made General Manager of the Pennsylvania & Western R.R. in 1891 and in 1912 was made President and General Manager of its successor, the Susquehanna, Bloomsburg & Berwick R.R.

William F. Ray, General Superintendent of the Boston & Maine R.R., whose death from heart disease in a Boston department store on Sept. 26, was briefly noted in our issue of last week, was born at South Vernon, Vt., in 1857, and was educated at the University of Notre Dame, South Bend, Ind. In 1874 he entered the employ of the Connecticut River R.R. as a locomotive fireman. He rose steadily in the freight service to be conductor, was then conductor in the passenger service, afterward being promoted to be Trainmaster and Assistant Superintendent. In 1903 he was made Superintendent of the Concord division of the Boston & Maine R.R. He was promoted to be General Superintendent in October of last year.

Dr. Rudolph Diesel, Hon. M. Am. Soc. M. E., of Munich, Germany, famous as the inventor of the Diesel oil engine, disappeared from the steamer "Dresden" en route from Antwerp to London on the night of Sept. 29. Dr. Diesel was on his way to London to attend the annual meeting of the Consolidated Diesel Engine Manufacturers. He was accompanied by Messrs. George Carels, a director, and Luckmann, Chief Engineer. The three men dined together, after which Dr. Diesel left the other two, to retire to his room for the night. At 6 o'clock in the morning, according to the reported interview of Mr. Carels, Dr. Diesel was first missed, and an investigation showed that his bed had not been slept in. There seems no room for doubt that he fell overboard through some mischance. Dr. Diesel was born in Paris, France, in 1858. He was educated in Germany at Augsburg and Munich, and very early specialized in thermo-dynamics. For years he carried on experiments with internal-combustion motors. For a while he practiced as a Consulting Engineer in Paris. The now famous Diesel engine made its first appearance in 1897, after four years of trials, and is now manufactured in practically all the industrial countries of the world. A history of the progress and development of the Diesel engine in the language of Dr. Diesel himself may be found in our issue of Apr. 4, 1912. Dr. Diesel was a member of the managing board of the Verein Deutscher Ingenieure and an Honorary Member of the American Society of Mechanical Engineers. He was a director of five of the leading companies building Diesel engines in Europe and the United States. During the recent visit to Germany of the American Society of Mechanical Engineers, Dr. Diesel was prominent in rendering hospitality to the visitors during their stay in Munich.

Arthur L. Adams, M. Am. Soc. C. E., Consulting Hydraulic Engineer, San Francisco, Calif., whose death at his home in Oakland, Calif., on Sept. 17, was briefly noted in our issue of last week, was one of the most prominent water-works engineers on the West coast. He was a lineal descendant of John Adams, who came to Plymouth Colony, Massachusetts, in the ship "Fortune" in 1621. He was born on a farm near Greensburg, Ind., and was educated in the district schools, the Greenburg High School, Hanover College, Indiana, and Washburn College, Topeka, Kan.; his technical education was received at Kansas State University, where he graduated in 1886, with the degree of B. S. in C. E. His first engineering work was as clerk to a Resident Engineer on construction of the Burlington & Missouri River R.R., in Nebraska, during the year following his graduation. In 1888 he was made Resident Engineer on construction of the Northern Pacific Ry., in Oregon and Washington. From 1889 to 1896 he was in private practice with headquarters at Pendleton, Ore.; during this time he prepared plans and specifications for the water-works systems of many of the thriving young municipalities of the Northwest. Mr. Adams took up his residence in San Francisco in 1896 and began to practice as a water-works expert. Between 1897 and 1900 he was in charge as Manager and Engineer of the West Los Angeles and West Side Water Cos., of Los Angeles, Calif., and reported upon water-works for Pasadena, Calif., and Missoula, Mont. In 1901 and 1902 he was Manager of the Contra Costa Water Works, supplying Ashland, Alameda, Berkeley and other towns in the vicinity of Oakland, Calif. In 1903 he resumed his private practice in San Francisco and was later identified with many city water-works and irrigation projects on the Pacific coast. During 1907-'08 he was in charge as Chief Engineer of the department of greater water-supply of the Peoples Water Co. (successor of the Contra Costa Water Co.), of San Francisco. Since then he had served the same company continuously in a consulting capacity. Mr. Adams is survived by a widow, three daughters and two sons.

ENGINEERING SOCIETIES
COMING MEETINGS

RAILWAY SIGNAL ASSOCIATION.
Oct. 14-16. Annual meeting at Nashville, Tenn. Secy., C. C. Rosenberg, Times Building, Bethlehem, Penn.

AMERICAN ELECTRIC RAILWAY ASSOCIATION.
Oct. 13-17. Annual convention at Atlantic City, N. J. Secy., H. C. Donecker, 29 West 39th St., New York City.

AMERICAN GAS INSTITUTE.
Oct. 15-17. Annual meeting at Richmond, Va. Secy., Geo. G. Ramsdell, 29 West 39th St., New York City.

NATIONAL SOCIETY FOR PROMOTION OF INDUSTRIAL EDUCATION.
Oct. 19-25. Annual convention at Grand Rapids, Mich. Secy., C. A. Prosser, 105 E. 22d St., New York City.

AMERICAN MINING CONGRESS.
Oct. 20-25. Annual convention at Philadelphia, Penn. Secy., J. Callbreath, Majestic Building, Denver, Colo.

AMERICAN RAILWAY BRIDGE AND BUILDING ASSOCIATION.
Oct. 21-23. Annual convention at Montreal, Que. Secy., C. A. Lichty, 319 North Waller Ave., Chicago, Ill.

NATIONAL ASSOCIATION OF RAILWAY COMMISSIONERS.
Oct. 28. Annual Convention at Washington, D. C. Secy., Wm. H. Connolly, Interstate Commerce Commission, Washington, D. C.

NATIONAL CONSERVATION CONGRESS.
Nov. 18-20. Annual meeting at Washington, D. C. Secy., T. R. Shipp, Indianapolis, Ind.

GREAT LAKES INTERNATIONAL PURE WATER ASSOCIATION.
Nov. 6-7. Meeting at Toronto, Ont. Secy., Paul Hansen, Urbana, Ill.

UNITED STATES GOOD ROADS ASSOCIATION.
Nov. 10-16. Third annual meeting at St. Louis, Mo. Secy., J. M. Rountree, Birmingham, Ala.

NATIONAL FOUNDERS ASSOCIATION.
Nov. 19-20. Annual convention at New York City. Secy., J. M. Taylor, 29 So. La Salle St., Chicago, Ill.

American Railway Safety Association—The second meeting of this association was held at the La Salle Hotel, Chicago, on Sept. 22. One of the subjects discussed was that of reducing accidents to trespassers, and an effort will be made to induce judges to be more severe in punishing persons arrested for trespassing. Another subject was the reduction of accidents to men on track and construction work. On the Northern Pacific Ry., a large proportion of these accidents occur where foreign laborers are employed, and steps are now being taken to get in touch with the interpreters at the boarding trains or camps and show them the necessity of warning the men against the dangers of their work. The President is A. W. Smallen (C., M. & St. P. Ry.); Secretary, L. F. Shedd (C,. R. I. & P. Ry.), Chicago.

National Machine Tool Builders' Association—The 12th annual convention will be held in New York City, Oct. 22-24, with headquarters at the Hotel Astor. The program is divided into seven sessions, and includes a number of addresses and committee reports. The second session of Oct. 23 and the morning session of Oct. 24, are devoted entirely to committee meetings. Somewhat of interest is felt in the coming report of the committee on the "Formation of a Mechanical Section."

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC.

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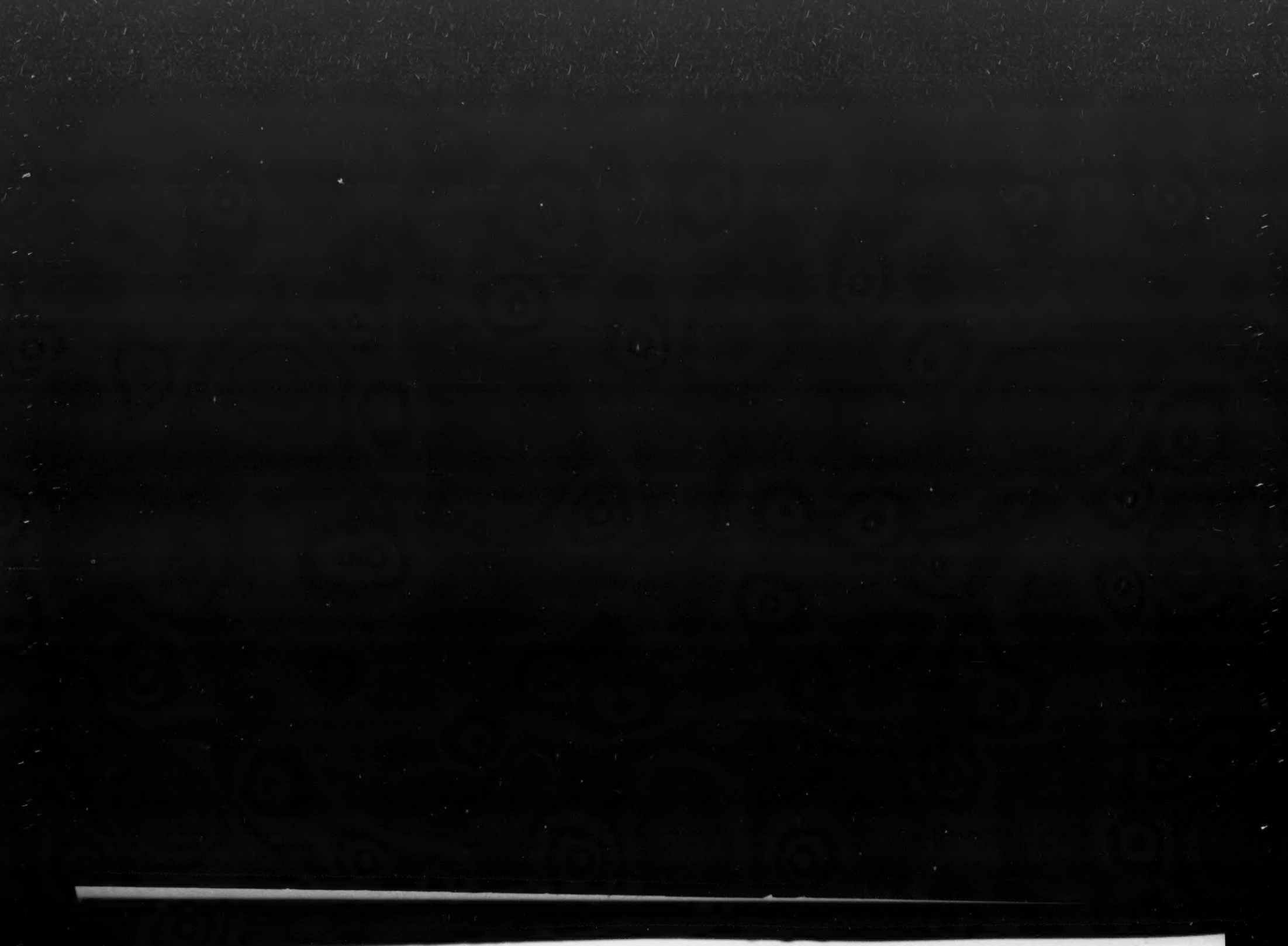
The balance of the stock issued (less than 1% each) is owned by 62 employees, one ex-employee, and 11 others who are wives, daughters or relatives of employees.

There are no bondholders, mortgagees, or other security holders.

C. W. Dibble, Vice-President,
HILL PUBLISHING COMPANY.

Sworn to and subscribed before me this 29th day of September, 1913.

RICHARD L. MURPHY,
Notary Public.
(My commission expires March 30, 1915)